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Ontario
Assessment
Instrument
Pool

Physics

PACKAGE V

SENIOR DIVISION



Ministry
of
Education
Ontario

Hon. Bette Stephenson, M.D., Minister
Harry K. Fisher, Deputy Minister

PHYSICS: Package V

SENIOR DIVISION

THE ONTARIO ASSESSMENT INSTRUMENT POOL

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This package contains selected response instruments: multiple choice and alternate response instruments. Most of the instruments are suitable for use at the Ontario Academic Course Level. However some instruments can be used to evaluate the aims, goals, and objectives of Senior Division Physics. Additional materials will be distributed as they become available.

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Constructing a Test

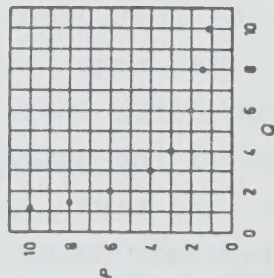
The following hints may be of assistance:

1. If more than one type of instrument is used in a test, group instruments of like format together, e.g. multiple choice instruments first, true-false instruments next, etc.
2. The size of the published instruments is ideal for making review transparencies. To save paper when making tests the instruments can be photoreduced by a factor of 64% and assembled as shown on the following page. However photo-reduction of selected response instruments involving measured quantities may result in the key not being among the choices or the key being a different choice than intended. An example illustrating this problem is included on the following page. Photoreduce instruments for tests, but be on the lookout for this fault.

1 How many significant digits are there in the number 0.340 050?

- (A) 3
- (B) 4
- (C) 5
- (D) 6
- (E) 7

2 The measured values of P and Q as obtained in an experiment were plotted as shown in the figure.



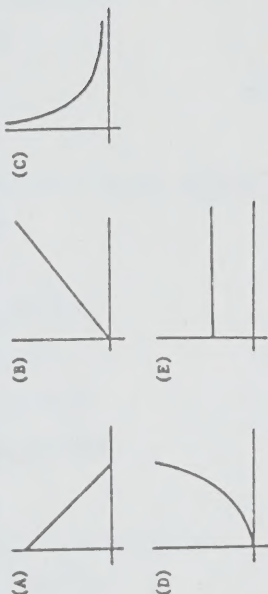
Which one of the following relationships best fits the experimental results?

- (A) $P \propto Q$
- (B) $P \propto Q^2$
- (C) $P \propto \frac{1}{Q}$
- (D) $P \propto \frac{1}{Q^2}$
- (E) $Q \propto \frac{1}{P^2}$

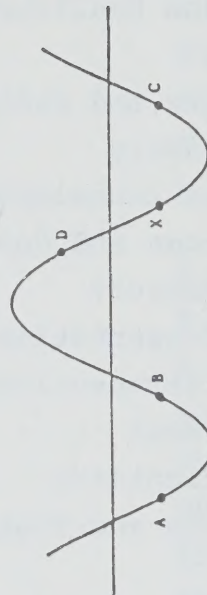
3 An object is thrown straight up from ground level with a speed of 50 m/s. Its distance above ground 1.0 s after being thrown is

- (A) 25 m
- (B) 30 m
- (C) 40 m
- (D) 45 m
- (E) 50 m

4 A cart is placed on a frictionless, horizontal surface and is moved by means of elastic bands of identical structure. The mass of the cart may be changed by placing masses on it. From the graphs below, select the one which best describes speed versus time when the cart is pulled by a force which is increasing uniformly with time.



5 The following diagram shows a transverse wave. Use a ruler to take any necessary measurements.



The wavelength of this wave is approximately

- (A) 12 cm
- (B) 6 cm
- (C) 4 cm
- (D) 3 cm
- (E) 2 cm

The key for the full sized instrument was B. The key for the photoreduction is C.

MEASUREMENT

1 A nanosecond is

- S17C (A) 10^9 s
I.1.a (B) 10^{-6} s
S 4 (C) 10^{-9} s
F1 (D) 10^{-10} s
(C) (E) 10^{-12} s

-
**

2 In an experiment to measure the force of friction
a student recorded the value (2.5 ± 0.1) N.

- S17A The relative error of this measurement is
I.1.d
S17C
I.1.a (A) 0.1
7 (B) 0.25
A2 (C) 0.04
F1 (D) 0.4
(C) (E) 4

-

3 The volume of a cylinder is given by $V = \pi r^2 h$,
where V is the volume, r is the radius, and h is
the height.

- S17A If the percentage error in the volume is 7% and
I.1.d the percentage error in the radius is 3%, then the
S17C percentage error in the height is
I.1.a

8

- (A) 1%
F1 (B) 4%
B5 (C) 10%
(D) (D) 13%
(E) Impossible to calculate from the given data.

4

The volume of a cylinder is given by $V = \pi r^2 h$, where V is the volume, r is the radius, and h is the height.

S17A

I.1.d

S17C

I.1.a

If the percentage error in the radius is 3% and the percentage error in the height is 11%, then the percentage error in the volume is

8

(A) 14%

F1

B5

(B) 17%

(B)

(C) 20%

(D) 33%

(E) Impossible to calculate from the given data.

5

The density of a substance is given by $D = m/V$, where D is the density, m is the mass, and V is the volume.

S17A

I.1.d

S17C

I.1.a

If the percentage error in the mass is 6% and the percentage error in the volume is 3%, then the percentage error in the density is

8

(A) 2%

F1

B5

(B) 3%

(C)

(C) 9%

(D) 18%

(E) Impossible to calculate from the given data.

6

S17A
I.1.d
S17C
I.1.a

The acceleration of an object moving in a circle at constant speed is given by $a = v^2/r$, where a is the acceleration, v is the speed, and r is the radius.

8

If the percentage error in the speed is 5%, and the percentage error in the radius is 4%, then the percentage error in the acceleration is

F1
B5

(C)

(A) 6%

(B) 9%

(C) 14%

(D) 21%

(E) 40%

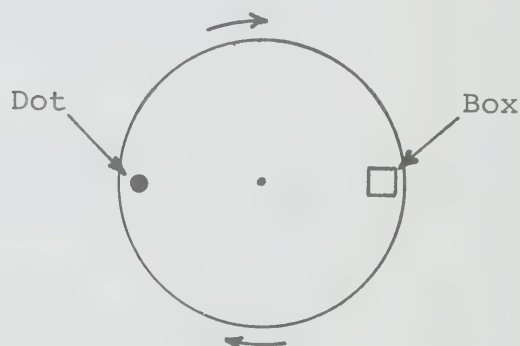
7

S17C
I.1.c
SS 8

F1

(C)

A black dot and a square box are drawn on one face of a circular disc. The disc makes sixty revolutions in six seconds. A blinking light shines on the rotating disc.



-

Which minimum blink frequency must the light have in order that the dot appears to be inside the box?

(A) 5.0 Hz

(B) 10 Hz

(C) 20 Hz

(D) 60 Hz

(E) 120 Hz

8

S17C
I.1.c

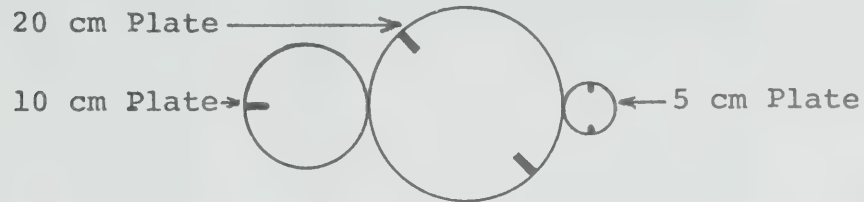
SS8

F1

(E)

-

The diagram below shows three circular plates in contact. Each plate is marked as shown. A variable speed motor drives the 10 cm diameter plate, which in turn drives the 20 cm diameter and the 5 cm diameter plates. There is no slippage.



The stroboscope produces this pattern on the 5 cm diameter plate.



Which pattern should appear on the 10 cm diameter plate if the strobe frequency is not altered?

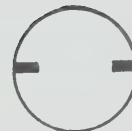
(A)



(B)



(C)



(D)



(E)



9

A mark is placed on the flywheel of an engine. The mark appears motionless when viewed through a 20 slit stroboscope which makes sixty revolutions in 10 s.

S17C
I.1.c

SS 8

Which one of the following frequencies of the fly-wheel's rotation is not possible?

F1

(A) zero

(B)

(B) 60 Hz

-

(C) 120 Hz

(D) 240 Hz

(E) 480 Hz

1

One nanometre is equivalent to 1×10^{-10} m.

S17A
I.1.c

(A) True

S17C
I.1.a

(B) False

4

A2

(B)

-

**

F U N C T I O N S

1

A set of experimentally gathered data is presented in the following table:

S17C
I.2.b

9

D3

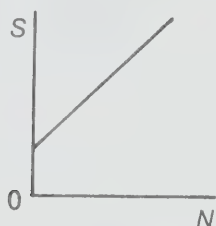
(D)

N	S
0	5
2	9
4	21
6	41
8	69

-
**

Which of the graphs below best illustrates the correct relationship between N and S ?

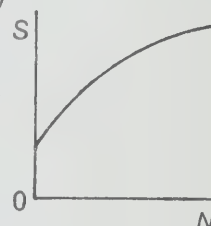
(A)



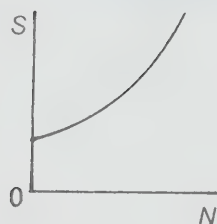
(B)



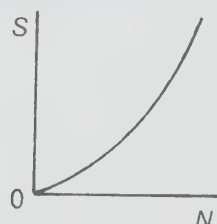
(C)



(D)



(E)



2S17C
I.1.d

S 9

A7

(D)

-

A pendulum consists of a mass attached to a string suspended from a rigid support. The period T of the pendulum, defined as the time required for one complete vibration, depends on the length of the string l and the acceleration due to gravity g . k is a dimensionless proportionality constant.

Using dimensional analysis, what is a possible equation for finding the size of the constant.

(A) $k = \frac{T}{lg}$

(B) $k = \frac{T}{\sqrt{lg}}$

(C) $k = \frac{Tg}{l}$

(D) $k = T\sqrt{\frac{g}{l}}$

(E) $k = \frac{T\sqrt{g}}{l}$

3

The geological past is often divided into eras and periods according to the chart below.

S17C

I.2.b

10

A11

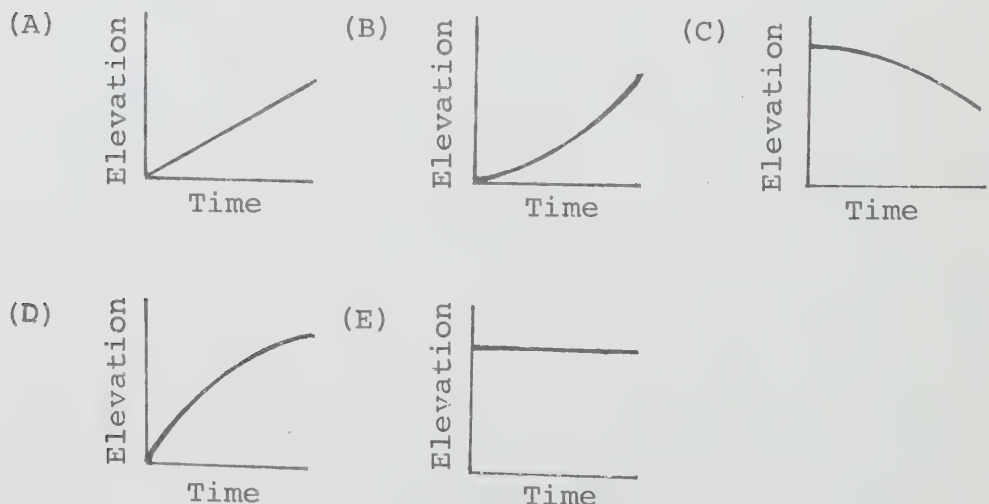
A7

(A)

-
**

Era	Period	Years elapsed to present
Cenozoic	Quaternary	present
	Tertiary	1.7×10^6
Mesozoic	Cretaceous	5.5×10^7
	Jurassic	1.2×10^8
	Triassic	1.3×10^8
Paleozoic	Carboniferous	1.5×10^8
	Devonian	2.7×10^8
	Silurian	3.0×10^8
	Ordovician	3.5×10^8
	Cambrian	3.8×10^8
Proterozoic	Pre-Cambrian	4.7×10^8
		1.0×10^9

Certain deposits at sea level at the end of the Triassic period were subsequently lifted to their present elevation of approximately 2 000 m above sea level. If the time rate of elevation has been constant, which graph best expresses the elevation of the deposit as a function of time?



4

Which of the following is not an expression of direct variation between x and y ?

S17C
I.2.b

(A) $y = kx$

S 10

(B) $y = kx + b$

A11
A2

(C) $y \propto x$

(B)

(D) $\frac{y}{x} = k$

-
**

(E) $k \frac{x}{y} = 1$

5

Which of the following is not an expression of direct variation between x and y ?

S17C
I.2.b

(A) $y = kx$

S 10

(B) $y = kx + b$

A11
A2

(C) $y \propto x$

(B)

(D) $\frac{y}{x} = k$

-
**

(E) a straight line graph passing through the origin

6

The power P developed by a motor varies directly as its frequency of rotation f .

S17C
I.2.b

This relation can be expressed by all of the following except

S 11

(A) $P \propto f$

F1

(B) $P = kf$

(C)

(C) $P = kf + b$

-
**

(D) $\frac{P_1}{P_2} = \frac{f_1}{f_2}$

(E) a straight line graph passing through the origin

7

The geological past is often divided into eras and periods according to the chart below.

S17C

I.2.b

12

A7

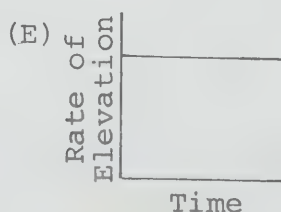
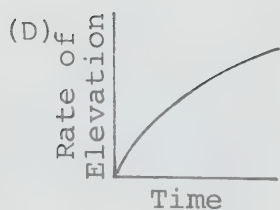
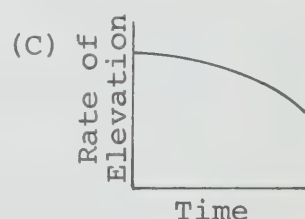
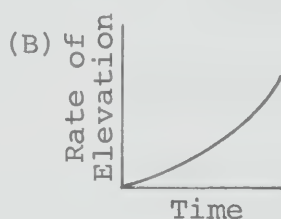
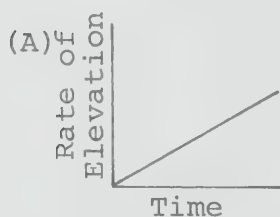
A11

(E)

-

Era	Period	Years elapsed to present
Cenozoic	Quaternary	present
	Tertiary	1.7×10^6
Mesozoic	Cretaceous	5.5×10^7
	Jurassic	1.2×10^8
	Triassic	1.3×10^8
Paleozoic	Carboniferous	1.5×10^8
	Devonian	2.7×10^8
	Silurian	3.0×10^8
	Ordovician	3.5×10^8
	Cambrian	3.8×10^8
Proterozoic	Pre-Cambrian	4.7×10^8
		1.0×10^9

Certain deposits at sea level at the end of the Triassic period were subsequently lifted to their present elevation of approximately 2 000 m above sea level. If the time rate of elevation has been constant, which of the graphs would best represent the rate of elevation as a function of time?



8

S17C
I.2.b

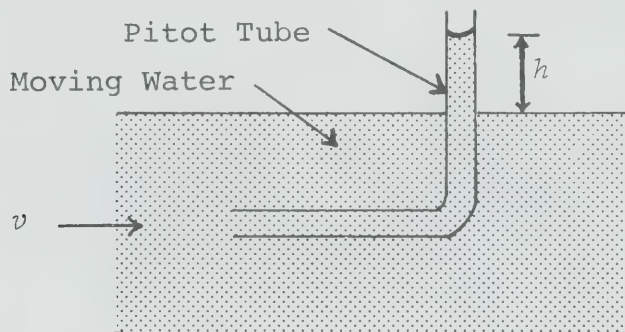
S 12

D3

(D)

-

The speed of moving water v can be measured using an L-shaped tube called a pitot tube. The pressure exerted by the moving water raises the height of the water in the vertical part of the tube to a height h above the surface as shown.



A set of experimental data for the pitot tube is shown in the following table.

speed v (m/s)	1.0	2.0	3.0	4.0	5.0	6.0
height h (m)	0.05	0.20	0.45	0.80	1.25	1.80

Which of the following proportionality statements best expresses the relationship illustrated by the data?

- (A) $h \propto v$
- (B) $h \propto \sqrt{v}$
- (C) $h \propto v^{-2}$
- (D) $h \propto v^2$
- (E) $h \propto v^3$

9

The strength s of a steel rod is directly proportional to its cross-sectional area A .

S17C

I.2.b

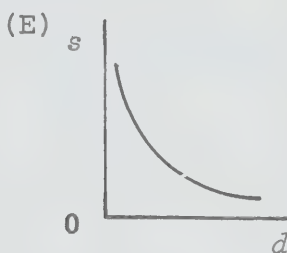
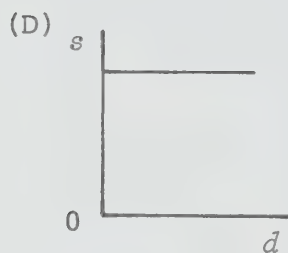
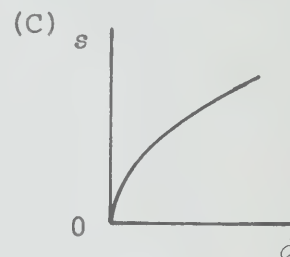
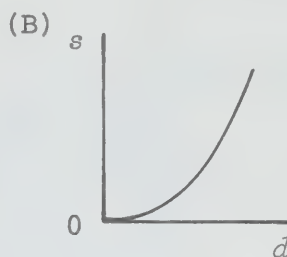
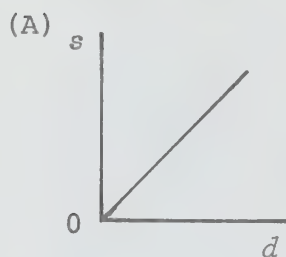
Which graph shows the relationship between the strength of a rod and its diameter d ?

S 13

A11

A5

(B)

-
***

10

Two drops of an oily liquid placed on water form a circular layer one molecule thick and of radius 20 cm.

S17C

I.2.c

Three drops of the same oily liquid would produce a circular layer one molecule thick and of radius

SS 13

F1

(A) 30 cm

(E)

(B) $20 \sqrt[3]{2.0}$ cm-
***(C) $20 \sqrt[3]{1.5}$ cm(D) $20 \sqrt{2.0}$ cm(E) $20 \sqrt{1.5}$ cm

11

A solid cylindrical shaft of radius r just supports a solid iron sphere of radius 2 cm.

S17C

I.2.c

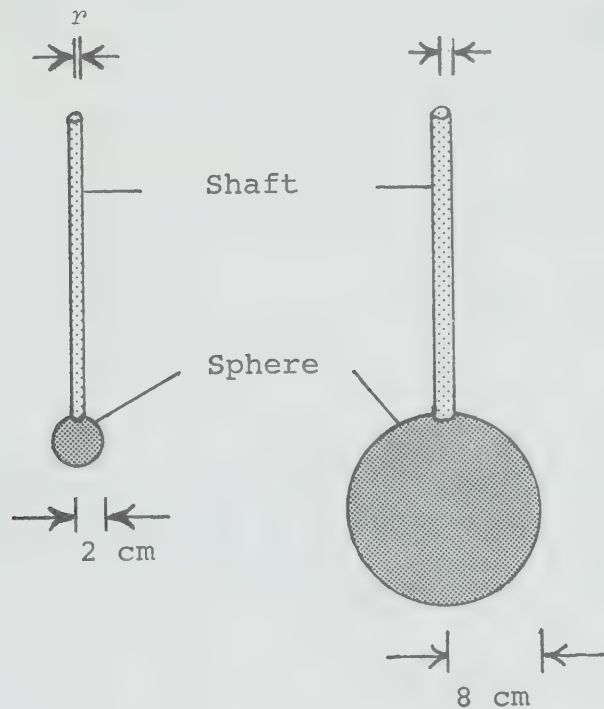
SS 13

What is the smallest radius of a cylindrical shaft that will support a sphere of radius 8 cm if the same materials are used each time?

F1

(D)

—



- (A) $2r$
- (B) $2\sqrt{2}r$
- (C) $4r$
- (D) $8r$
- (E) $16r$

12

A rotating stroboscope with n slits open has a frequency of f Hz.

S17C

I.1.c

What is the viewing frequency in Hz?

SS 13

(A) nf

F1

(B) $\frac{f}{n}$

(A)

(C) $\frac{n}{f}$

-

(D) $\frac{nf}{60}$ (E) $\frac{60}{nf}$ **13**

Assume that explorers of outer space find a planet with horses having all linear dimensions scaled up by a factor of 4 compared to horses on earth.

S17C

I.2.c

What is the strength to mass ratio of a horse on the planet compared to a horse on earth?

SS 13

F1

(A) the same

(B)

(B) 1:4

-

(C) 4:1

(D) 1:16

(E) 16:1

1

One conclusion that can be correctly drawn from the graph shown is that $AB = k$, where k is the slope of the graph.

S17C

I.2.b

11

A11

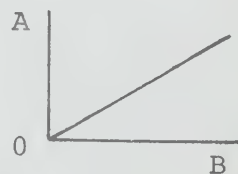
(A) True

(B)

(B) False

-

*



K I N E M A T I C S

MOTION IN A STRAIGHT LINE

1

Which of the following speed-time graphs best illustrates a car braking to a stop?

S17A
I.2.a
S17C
I.3.b

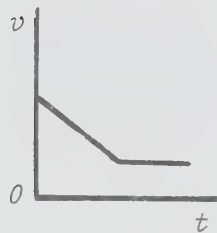
14

All

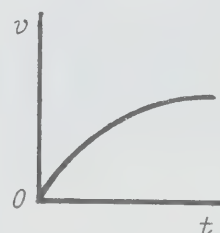
(D)

-
*

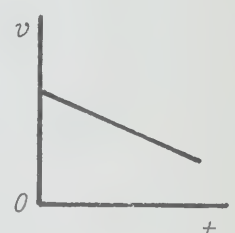
(A)



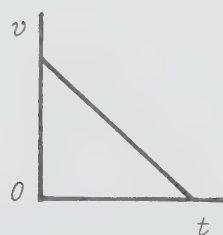
(B)



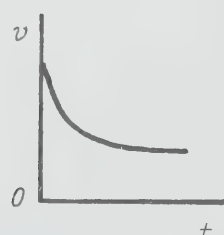
(C)



(D)



(E)



2

S17C
I.3.a

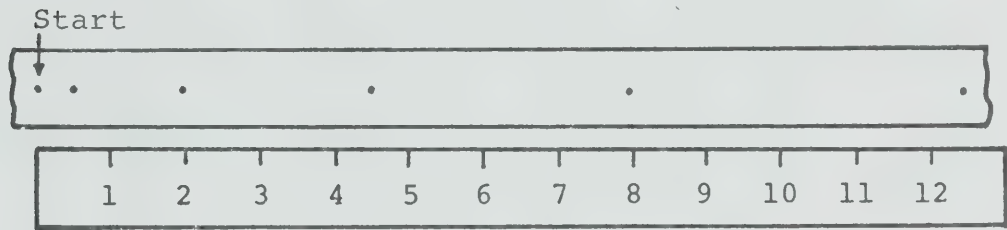
S 14

F1

(B)

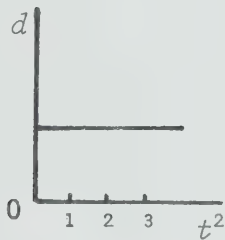
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The tape from a laboratory experiment using a recording timer has the appearance shown below. A ruler graduated in cm is shown below the tape.

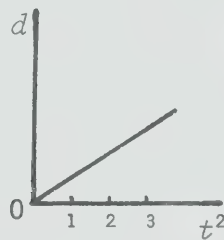


Which one of the following graphs could be the distance-(time)² graph?

(A)



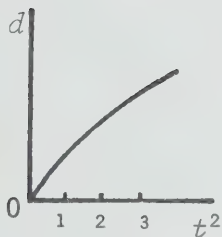
(B)



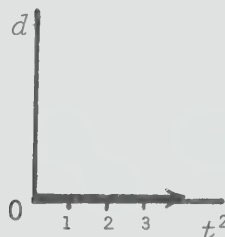
(C)



(D)



(E)



3

S17C
I.1.c

S 14

F1

(C)

-

A stroboscope with 20 open slits has a frequency of 3 Hz. A vibrating bell clapper viewed through it appears as in the diagram.

The frequency of vibration of the bell clapper could be

(A) 3 Hz

(B) 20 Hz

(C) 30 Hz

(D) 60 Hz

(E) 120 Hz



4

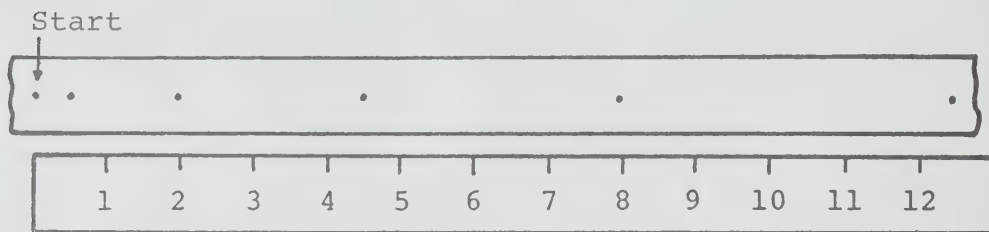
S17C
I.3.a

S 14

F1

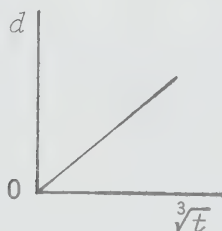
(D)

The tape from a laboratory experiment using a recording timer has the appearance shown below. A ruler graduated in cm is shown below the tape.

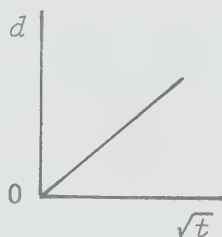


Which one of the graphs shown below correctly describes the motion of the tape?

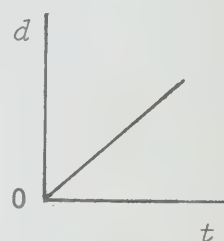
(A)



(B)



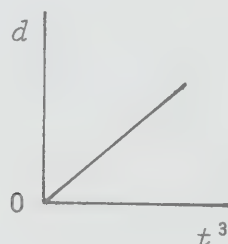
(C)



(D)



(E)



5

S17C
I.1.c

S 14

F1

A2

(A)

A vibrating saw blade clamped in a vice appears as shown below when seen through a 12 slit disc stroboscope.

If the disc rotates 20 times in 5.0 s, the frequency of the saw blade can be

(A) 24 Hz

(B) 48 Hz

(C) 60 Hz

(D) 1.0×10^2 Hz(E) 1.2×10^2 Hz

6 The position-time graph of an object moving due north is a straight line with a positive slope.

S17C

I.3.a

This means that the object has a

15

(A) constant displacement.

A2

(B) steadily increasing acceleration.

A11

(C) steadily decreasing acceleration.

(D)

(D) constant velocity.

-

**

(E) steadily increasing velocity.

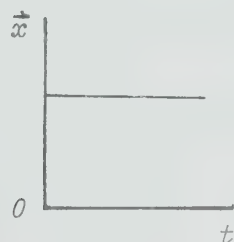
7 Which one of the following graphs best represents position $\vec{x}$ versus time t for an object which is moving along a straight path with constant speed?

S17C

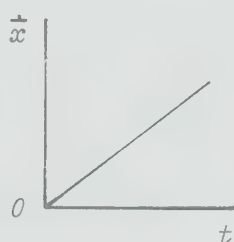
I.2.a

15

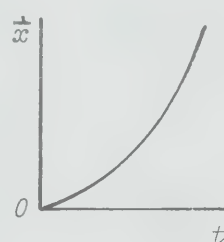
(A)



(B)



(C)



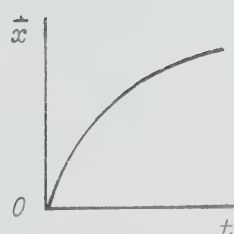
A11

(B)

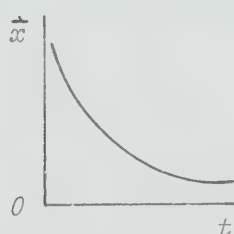
-

*

(D)



(E)



8

Three cars P, Q, R travel separately in a straight line from X to Y. The distance-time graph of each car's motion is plotted below.

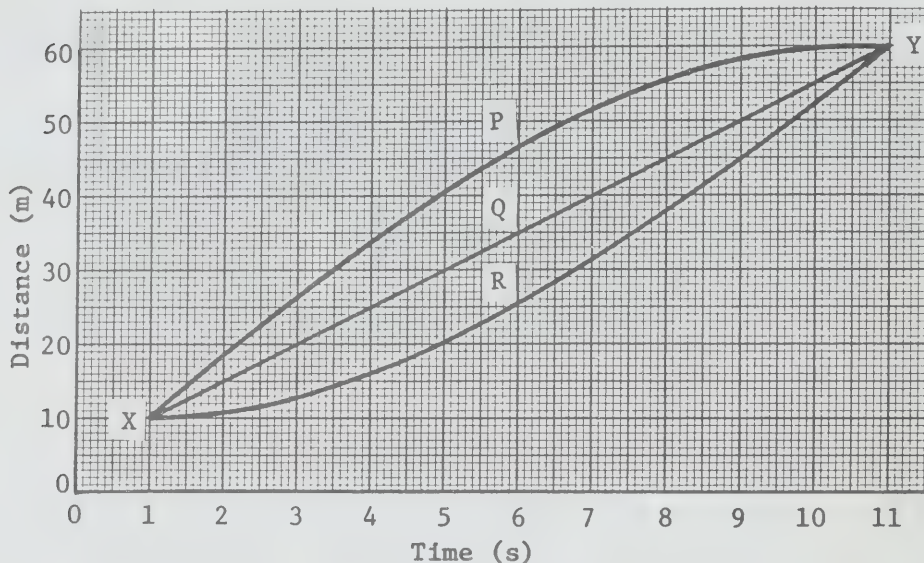
S17C

I.3.a

S 15

F1

(D)

-
**

Which one of the following statements is true?

- (A) Q's motion is an example of positive acceleration.
- (B) P reaches Y in less time than either Q or R.
- (C) Eight seconds after P leaves X its speed is approximately 58 m/s.
- (D) P moves more slowly than either Q or R during the last 10 m before Y.
- (E) R's average speed from X to Y is less than the average speeds of either P or Q from X to Y.

9

S17C
I.3.a

S 15

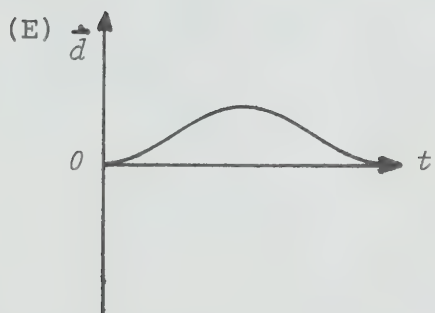
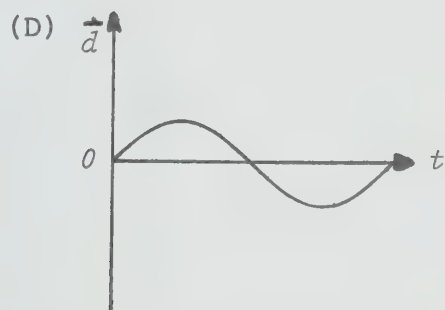
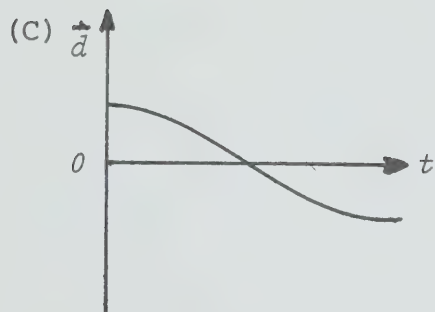
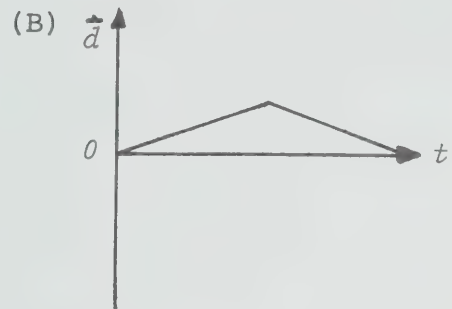
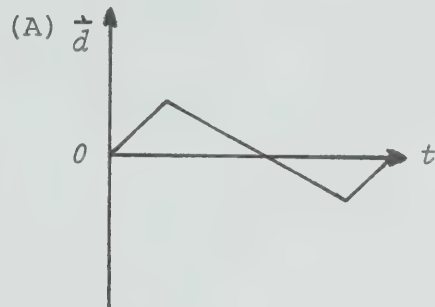
F1

(E)

-

A car accelerates from rest down a straight road. A short time later the car stops and backs up to the starting point.

Which of the following displacement-time graphs best illustrates the motion of the car?



10

The graph below was drawn from data obtained when a styrofoam ball was dropped from rest.

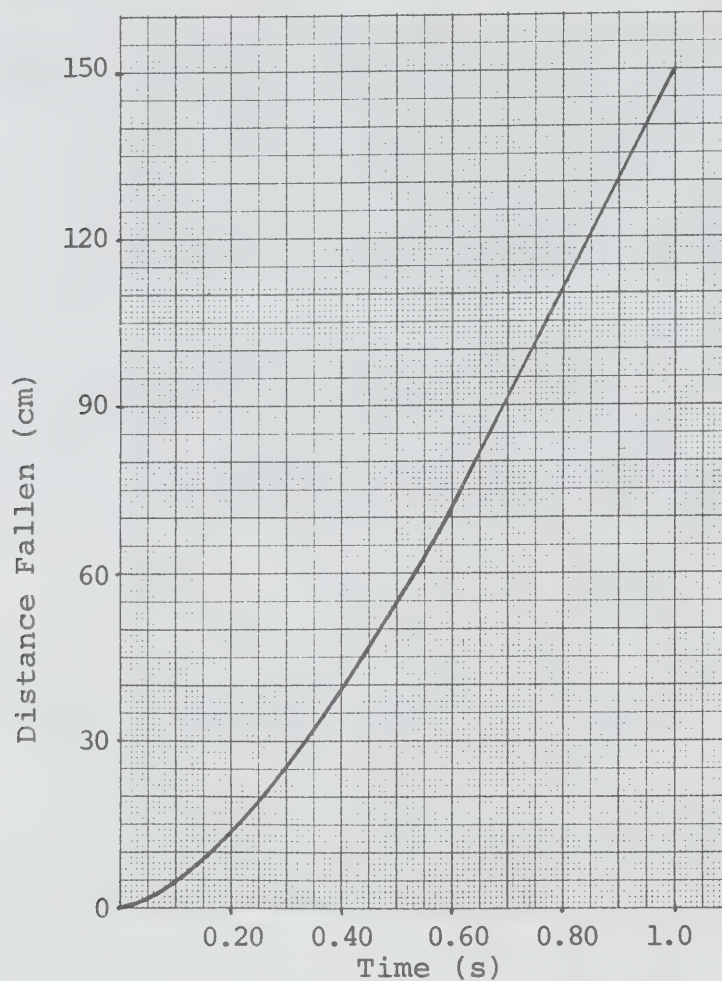
S17C
I.3.a

16

F1
D3

(D)

-



The speed of the ball at 0.20 s was most nearly

- (A) 0.28 cm/s
- (B) 14 cm/s
- (C) 70 cm/s
- (D) 1.0×10^2 cm/s
- (E) 1.5×10^2 cm/s

11

An object has an acceleration of 3 m/s^2 .

S17C
I.3.a

The displacement versus time graph for the object has a slope

16

(A) that is constant

A8

(B) that increases with time

(B)

(C) that decreases with time

-
**

(D) of three metres per second

(E) of three metres per second squared

12

S17C
I.4.c

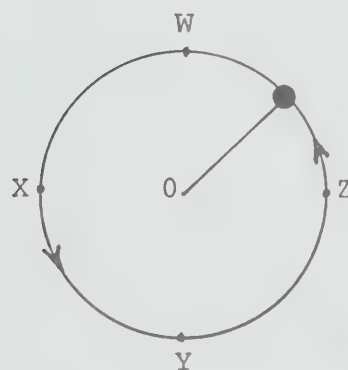
S 16

A2

(B)

-
**

The diagram shows an object tied to the end of a string. The object moves counterclockwise in a circle at constant speed on a frictionless level surface. The distance travelled by the object in moving from W to X is 25 m. It takes the object 20 s to complete one revolution.



What is the direction of the velocity of the object when at Z?

(A)



(B)



(C)



(D)



(E)



13

The air resistance on a falling object is directly proportional to the square of its velocity.

S17C

I.3.b

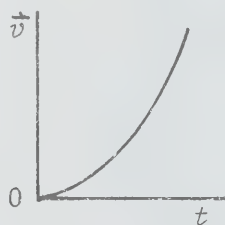
Based on this relationship, which of the following velocity-time graphs best represents a 10 kg mass falling to the earth from a height of 1000 m?

S 16

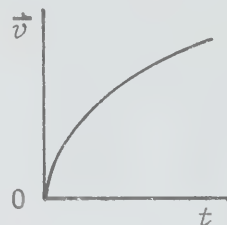
A11

(C)

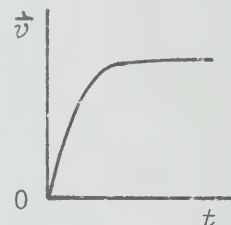
(A)



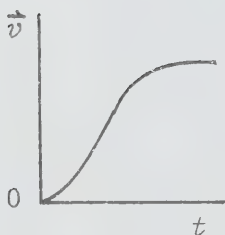
(B)



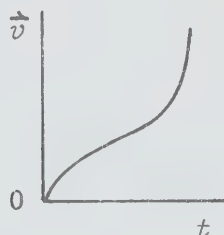
(C)



(D)



(E)



14

S17C
I.4.a

S 16

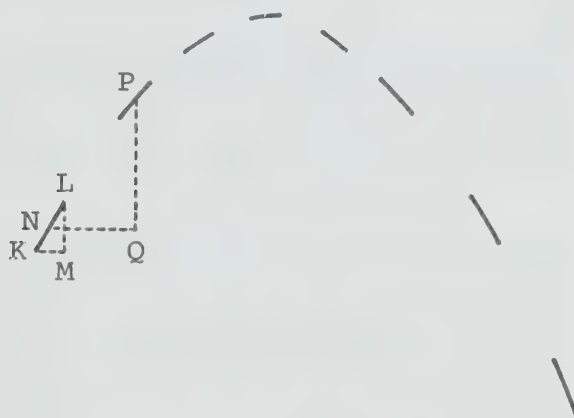
D3
A8
A11

(A)

-

The figure below represents a multiple-flash photograph taken by an experimenter while studying the motion of a steel ball projected into the air. The ball was photographed through a narrow slit near the edge of a disc spinning at constant speed. The black streaks indicate the path of the ball during the intervals when the slit is in front of the open camera shutter. Sets of measurements which can be made on such a photo include:

- the length of each streak, such as KL
- the horizontal extent of each streak, such as KM
- the vertical extent of each streak, such as LM
- the horizontal distance between the centres of successive streaks, such as NQ
- the vertical distance between the centres of successive streaks, such as QP



Which set of measurements will give the most direct indication of the magnitude of the ball's speed at various times?

- (A) the length of each streak
- (B) the horizontal extent of each streak
- (C) the vertical extent of each streak
- (D) the horizontal distance between the centres of successive streaks
- (E) the vertical distance between the centres of successive streaks

15

S17C
I.3.a

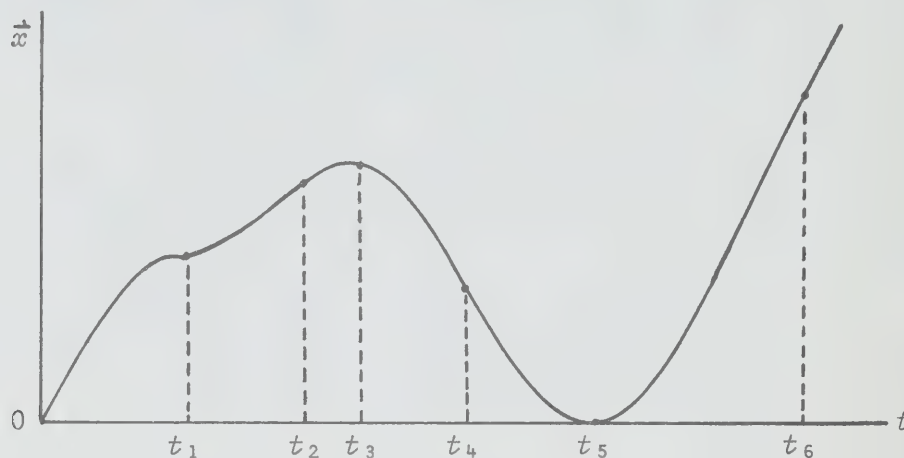
S 16

F1

(E)

-
**

A sea-going rat is trying to decide whether to leave a ship which it suspects is unseaworthy. The graph records the rat's position $\vec{x}$ with reference to the ship as it scampers along one of the ropes tying the ship to the pier.



If the ship is the origin, and motion away from the ship is positive, select the false statement.

- (A) The rat's velocity at t_6 is greater than its velocity at t_2 .
- (B) The rat's final decision is to leave the ship.
- (C) The algebraic sign of the rat's velocity from t_3 to t_5 is negative.
- (D) At t_5 , the rat is at the ship.
- (E) The algebraic sign of the rat's acceleration at t_5 is negative.

16

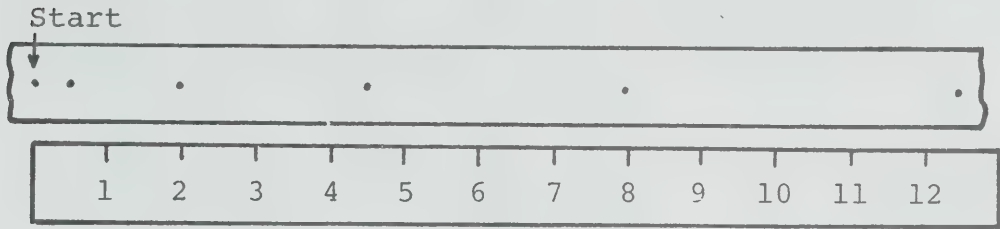
The tape from a laboratory experiment using a recording timer has the appearance shown below.

SL7C
I.3.b

S 16

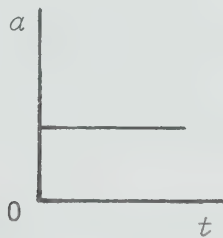
F1

(A)

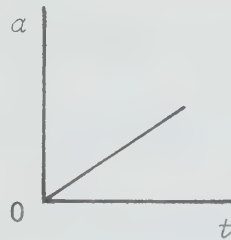


Which of the following graphs could be the acceleration-time graph?

(A)



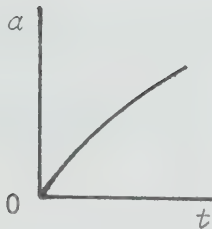
(B)



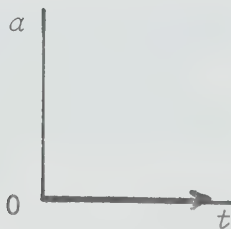
(C)



(D)



(E)



17

The graph shows the velocity versus time for a car moving north along a smooth road.

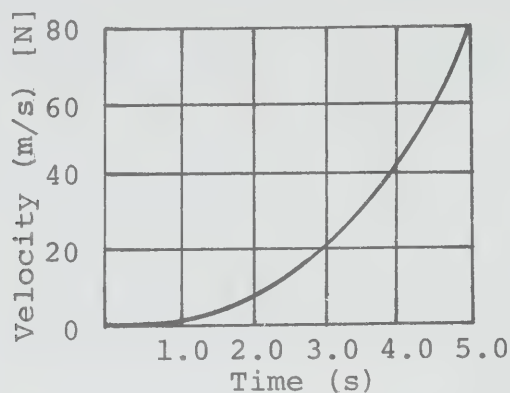
S17C
I.3.b

17

A7

(E)

-
**



In order to calculate the acceleration of the car 3.0 s after the time $t = 0$, one must

- (A) calculate the area under the curve from time $t = 0$ to time $t = 3.0$ s.
- (B) calculate the slope of the straight line joining time $t = 0$ and time $t = 3.0$ s.
- (C) divide the velocity of 20 m/s by the time of 3.0 s.
- (D) calculate the area under the curve from time $t = 2.0$ s to time $t = 4.0$ s.
- (E) calculate the slope of the tangent to the curve at time $t = 3.0$ s.

18

S17C
I.3.b

17

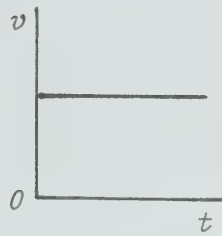
All

(B)

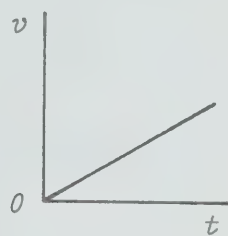
-

Which graph best represents a speed-time graph for a falling object for which air resistance can be ignored?

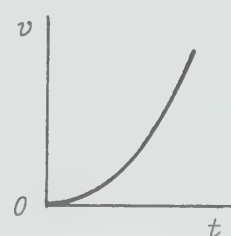
(A)



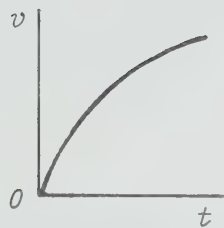
(B)



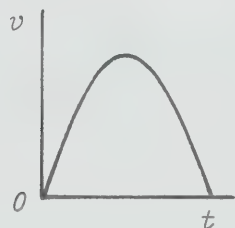
(C)



(D)



(E)



19

S17C
I.2.a

17

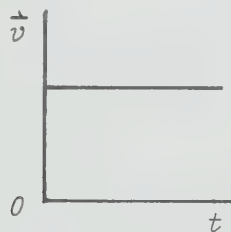
All

(B)

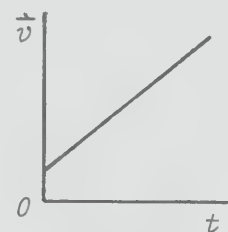
-
*

Which one of the following graphs best represents velocity versus time for a moving object which has constant positive acceleration?

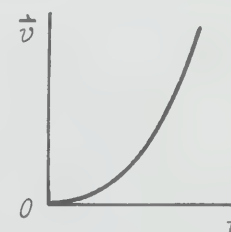
(A)



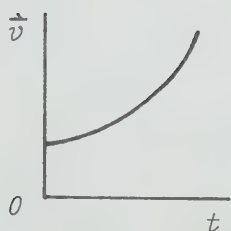
(B)



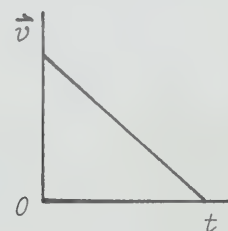
(C)



(D)



(E)



20

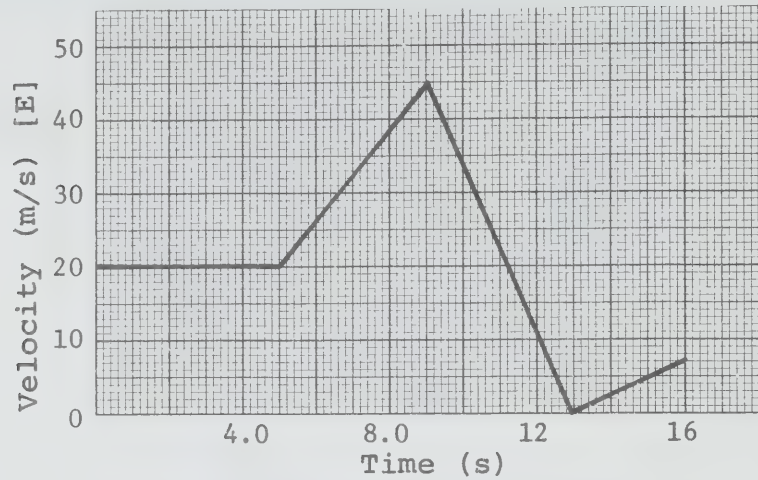
The velocity-time graph for an object is shown below.

S17C
I.3.b

17

A11
F1

(B)

-
**

The instantaneous acceleration of the object at 7.0 s is

- (A) zero
- (B) 6.3 m/s^2 [E]
- (C) 13 m/s^2 [E]
- (D) 20 m/s^2 [E]
- (E) 34 m/s^2 [E]

21

S17C

I.3.b

17

F1

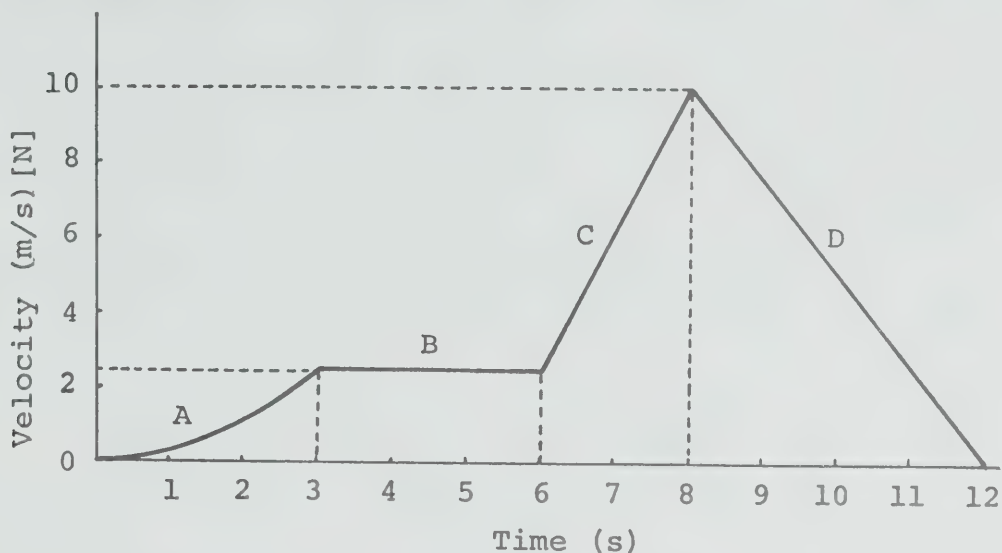
A7

A3

(D)

-

The following graph illustrates the variation of velocity with time for a particle which moves in a straight line path. The graph is divided into sections A, B, C, and D.



Which section of the graph represents an average acceleration having a magnitude of 2.5 m/s^2 ?

- (A) A
- (B) B
- (C) C
- (D) D
- (E) None of these

22

An object moves in a straight line as described by the graph below.

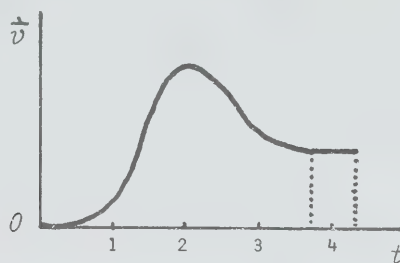
S17C
I.3.b

17

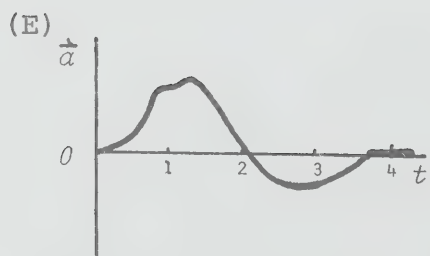
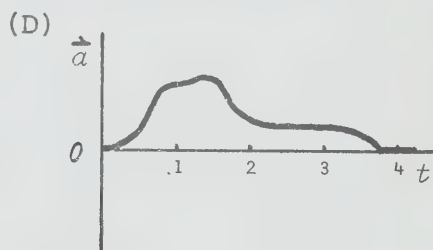
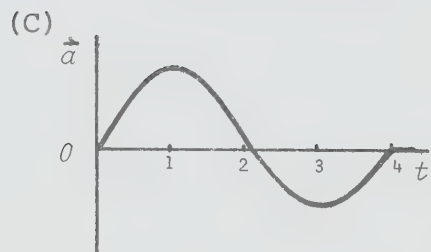
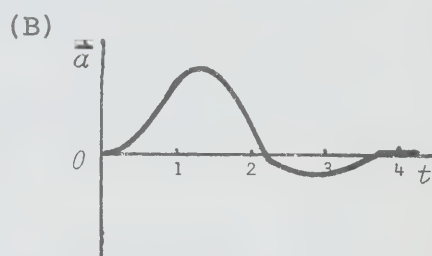
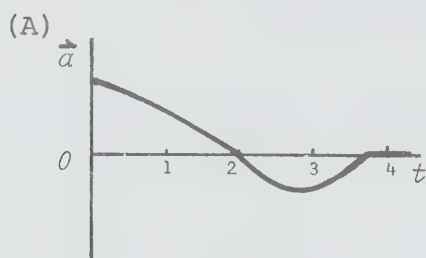
F1
A11
A7

(B)

~



Which of the following graphs best represents the acceleration of the object as a function of time?



23

Which graph below indicates a constant speed?

S17C
I.3.b

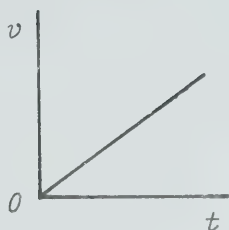
17

All

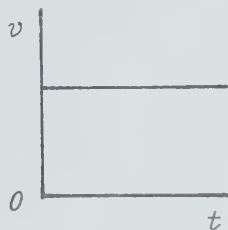
(B)

-
*

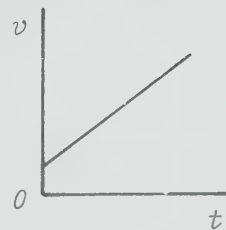
(A)



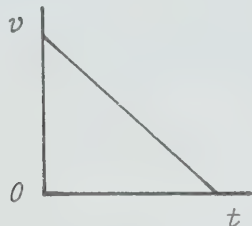
(B)



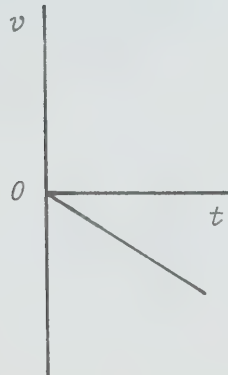
(C)



(D)



(E)



24

Which one of the following graphs would be the acceleration-time graph for an object moving at a uniform velocity of 20 m/s [E]?

S17C
I.3.b

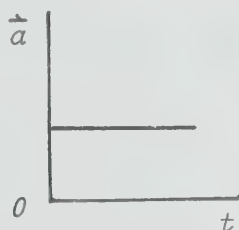
S 17

All

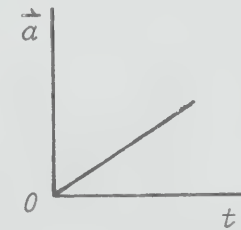
(E)

-

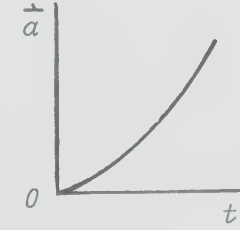
(A)



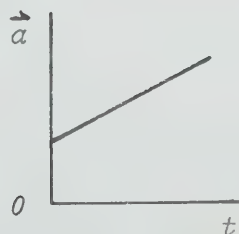
(B)



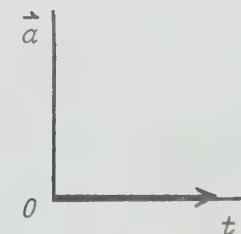
(C)



(D)



(E)



25

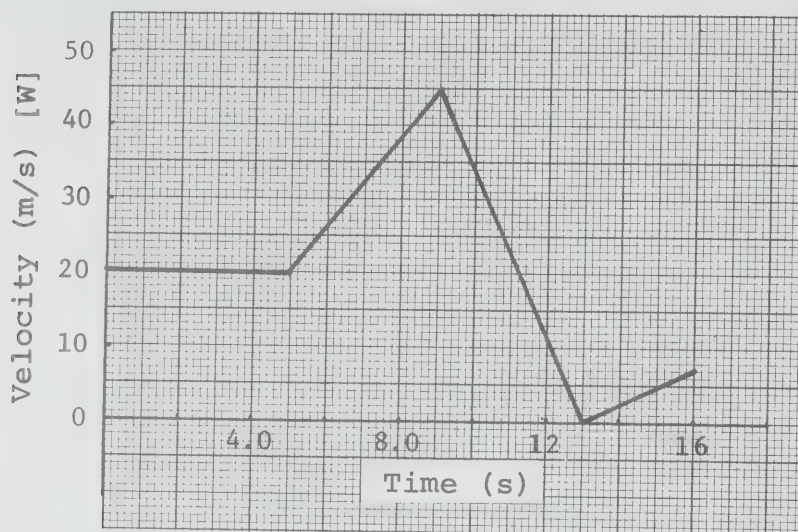
The velocity-time graph for an object is shown below.

S17C
I.3.b

18

All
F1

(C)

-
**

The displacement of the object during the first 9.0 s is

- (A) 4.5×10^1 m [W]
(B) 1.8×10^2 m [W]
(C) 2.3×10^2 m [W]
(D) 2.9×10^2 m [W]
(E) 4.3×10^2 m [W]

26

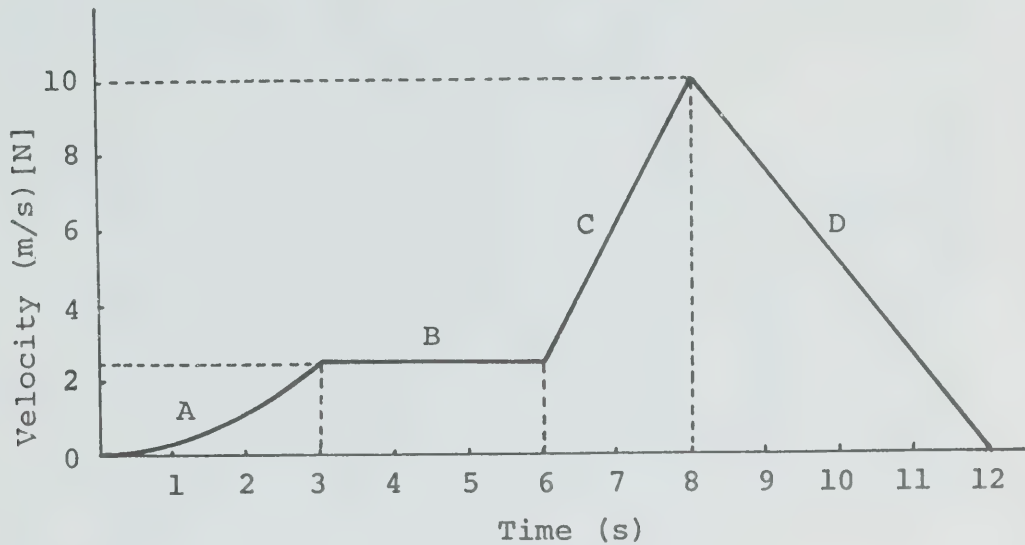
S17C
I.3.b

The following graph illustrates the variation of velocity with time for a particle which moves in a straight line path. The graph is divided into sections A, B, C, and D.

18

F1
A7
A3

(B)

-
**

During which section of the graph would the position-time graph for the particle be a straight line?

- (A) A
- (B) B
- (C) C
- (D) D
- (E) None of these

27

S17C
I.3.b

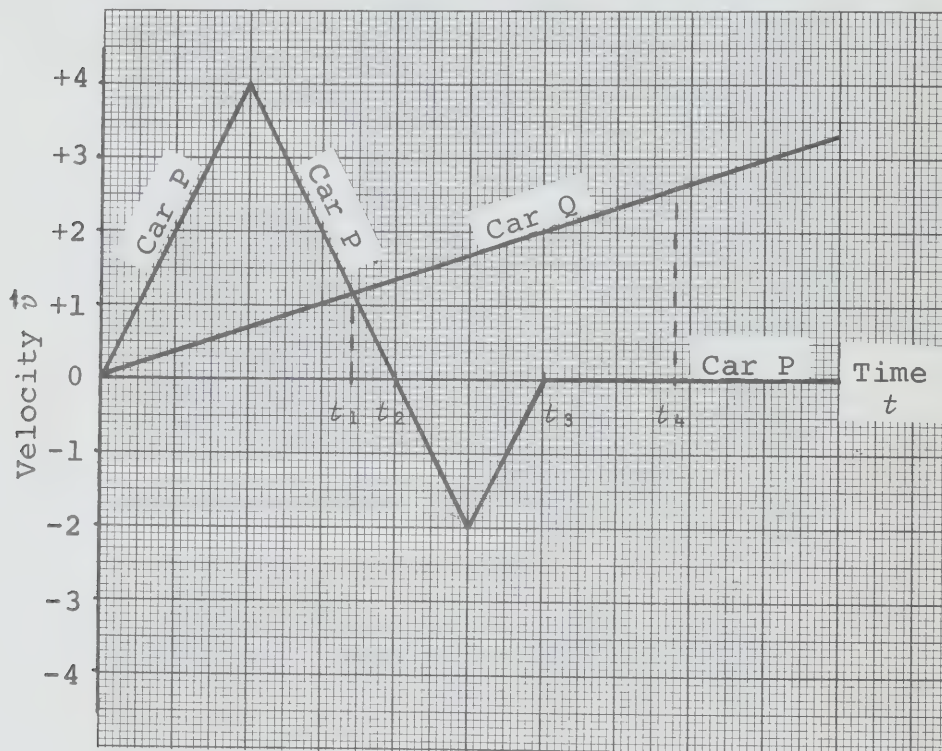
18

F1
A7

(C)

-

Car P and Car Q begin travelling simultaneously from the same point along a straight road. Velocity-time graphs of their motions are shown below.



Which one of the following statements is correct?

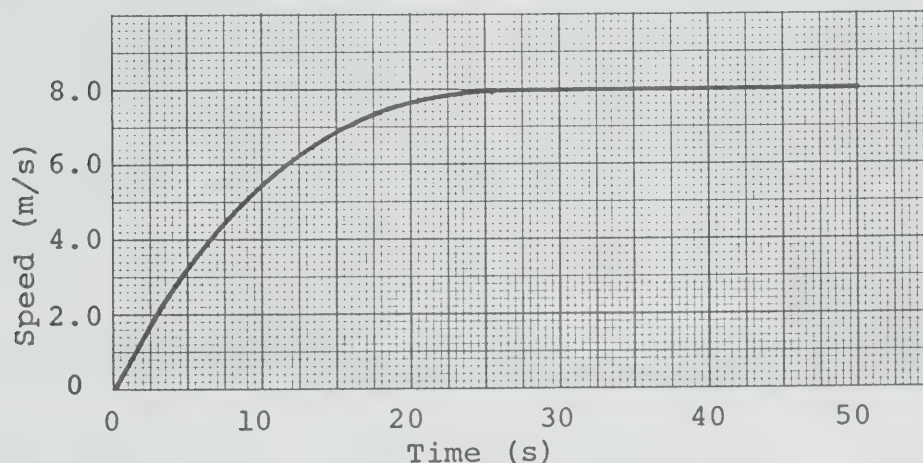
- (A) Car Q passes Car P at time t_1 .
- (B) Car Q passes Car P at time t_2 .
- (C) Car Q passes Car P at time t_3 .
- (D) Car Q passes Car P at time t_4 .
- (E) Car Q does not pass Car P.

28 A locomotive has a mass of 1.0×10^5 kg. The engineer operates it, when no cars are being pulled, in such a way that the engine exerts the maximum possible force at any speed. The force depends on the speed. The speed of the locomotive, as a function of time, under these conditions, is shown in the graph below.

A7
F1
A11

(D)

-
**



The distance travelled in the first 20 s is

- (A) 1.6×10^2 m
- (B) 1.4×10^2 m
- (C) 7.0×10^1 m
- (D) between 7.0×10^1 m and 1.4×10^2 m
- (E) less than 7.0×10^1 m

29

An object is released from a height of 11 m.

S17C
I.3.c

Which one of the following best represents the displacement of the object 1.0 s after it falls freely from rest? ($g = 10 \text{ m/s}^2$)

21

(A) 1.0 m

A8

(B) 2.5 m

(C)

(C) 5.0 m

-

**

(D) 10 m

(E) 11 m

30

An object initially at rest accelerates at 7.0 m/s^2 for 10 s.

S17C
I.3.c

What distance is covered by the object in this time?

21

(A) $7.0 \times 10^3 \text{ m}$

A8

(B) $3.5 \times 10^3 \text{ m}$

(D)

(C) $7.0 \times 10^2 \text{ m}$

-

**

(D) $3.5 \times 10^2 \text{ m}$

(E) $3.5 \times 10^1 \text{ m}$

31

How long would it take a truck to increase its speed from 10 m/s to 30 m/s if it does so with uniform acceleration over a distance of 80 m?

S17C
I.3.c

(A) 2.0 s

21

(B) 4.0 s

F1

(C) 5.0 s

(B)

(D) 8.0 s

-

**

(E) The time cannot be calculated since the acceleration is not given.

32

S17C
I.4.a

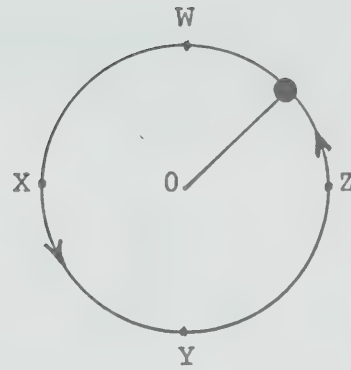
S 21

A2

(E)

-
**

The diagram shows an object tied to the end of a string. The object moves counterclockwise in a circle at constant speed on a frictionless level surface. The distance travelled by the object in moving from W to X is 25 m. It takes the object 20 s to complete one revolution.



What is the direction of the displacement of the object in travelling from W to X?

(A)



(B)



(C)



(D)



(E)



33

S17C
I.4

S 21

A11

(D)

-

In the equation $\vec{\Delta x} = \vec{v}_i \Delta t + \frac{1}{2} \vec{a} (\Delta t)^2$, the product $\vec{v}_i \Delta t$ represents

- (A) the initial displacement at the start of time interval Δt .
- (B) the product of initial velocity and the time interval during which the object is moving at the initial velocity.
- (C) the displacement before the object begins to accelerate.
- (D) what the displacement would have been in the time interval Δt for an acceleration of zero.
- (E) nothing meaningful when isolated from the total equation.

34S17C
I.3.a

S 21

A11

(C)

A stone is dropped from a cliff. The graph which best represents its motion during the first 5 s of fall is

(A)



(B)



(C)



(D)



(E)



35

S17C

I.3.b

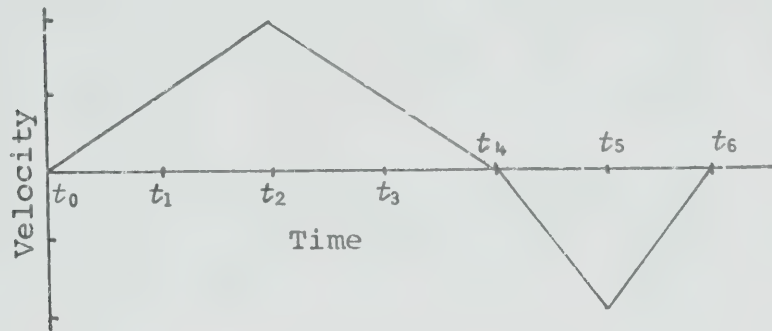
S 21

All

(B)

-

A car starting from rest at time t_0 ends up at position X at time t_6 . The motion of the car during this time interval is shown on the graph.



Which of the following statements describes the motion of the car?

- (A) The car reached position X at time t_4 , stopped at time t_5 and returned to position X at time t_6 .
- (B) The car passed through position X at time t_2 , went beyond X until time t_4 and returned to position X at time t_6 .
- (C) The car accelerated until time t_4 , decelerated until time t_5 and accelerated until time t_6 .
- (D) The car left position X at time t_0 , went beyond position X until time t_4 and returned to position X at time t_6 .
- (E) The speed of the car increases until time t_2 , then decreases until time t_5 and then increases until time t_6 .

36

The following graph represents an acceleration-time graph during a 5.0 s time interval for an object starting from rest.

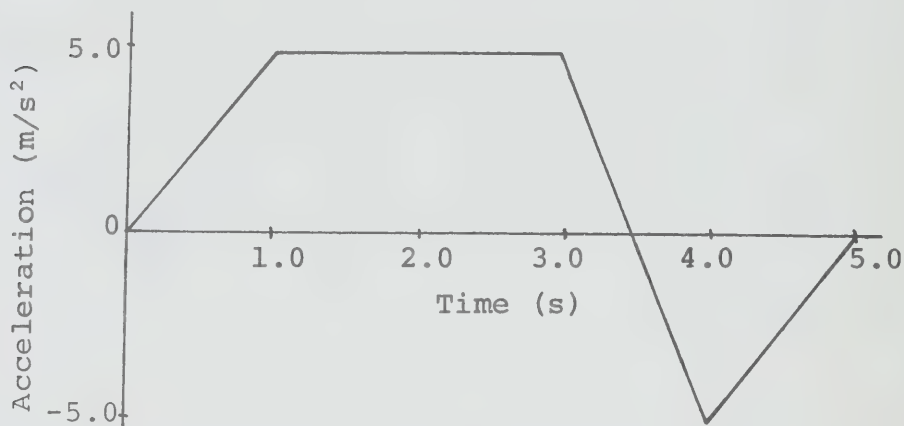
S17C
I.3.b

S 21

A11
A7
A3

(D)

-



The object's velocity at 5.0 s is

- (A) -5.0 m/s
- (B) zero
- (C) 5.0 m/s
- (D) 10 m/s
- (E) 18 m/s

37

An object starting from rest has an acceleration of 8.0 m/s^2 . After 10 s it has covered a distance of

S17C
I.3.c

S 21

F1

(D)

-
**

- (A) 40 m
- (B) 80 m
- (C) 320 m
- (D) 400 m
- (E) 800 m

38

S17C

I.3.b

S 21

A11

A7

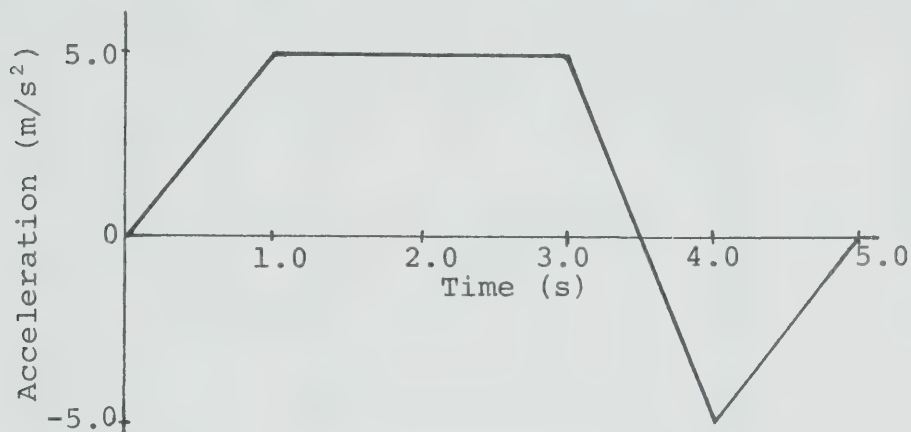
A3

(E)

-

**

The following graph represents an acceleration-time graph during a 5.0 s time interval for an object starting from rest.



When is the acceleration of the object zero?

- (A) at time zero only
- (B) during the interval 1.0 s to 3.0 s
- (C) at 3.5 s only
- (D) at zero and 5.0 s only
- (E) at zero, 3.5 s and 5.0 s

39

S17C

I.3.c

S 21

S 22

F1

(D)

-

If a man travels with a velocity of 20 m/s west for 10 s and then without stopping accelerates at 3 m/s² east for 4 s, what is his total displacement after 14 s?

- (A) 96 m west
- (B) 144 m west
- (C) 240 m west
- (D) 256 m west
- (E) 304 m west

40

The following graph represents an acceleration-time graph during a 5.0 s time interval for an object starting from rest.

S17C
I.3.b

S 21

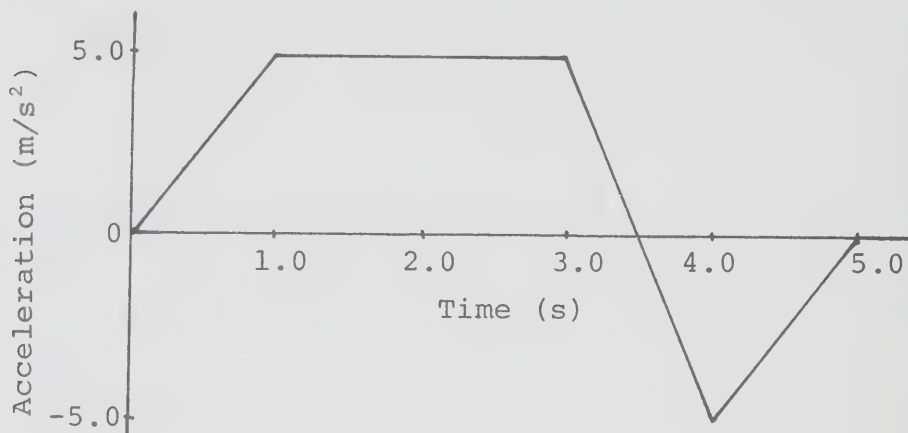
A11

A7

A3

(E)

-



Other than at time zero, when is the velocity zero?

- (A) during the interval 1.0 s to 3.0 s
- (B) at 3.5 s
- (C) at 4.0 s
- (D) at 5.0 s
- (E) at no time

41

How far does a free-falling body fall from rest in 3.0 s? ($g = 10 \text{ m/s}^2$)

S17C
I.3.c

S 21

F1

(C)

-
**

- (A) 15 m
- (B) 30 m
- (C) 45 m
- (D) 60 m
- (E) 90 m

4 2

S17C

I.4

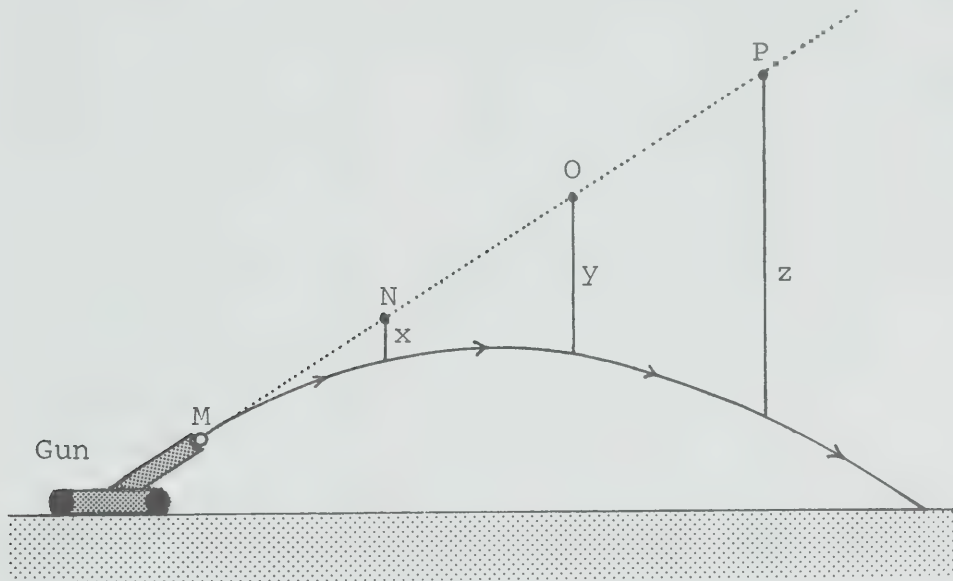
S 21

F1

(B)

-

If air friction is neglected, the motion of a projectile can be considered to be made up of an unchanging motion along the initial direction shown by the line MNOP and a free fall from that line represented by the line segments x , y , and z .



If the points M, N, O, and P are one second apart, what length are the line segments x , y , and z ? ($g = 10 \text{ m/s}^2$)

- (A) 5 m, 10 m, and 15 m
- (B) 5 m, 20 m, and 45 m
- (C) 10 m, 40 m, and 90 m
- (D) 10 m, 20 m, and 30 m
- (E) 0.2 m, 0.8 m, and 1.8 m

43S17C
I.4.e

S 21

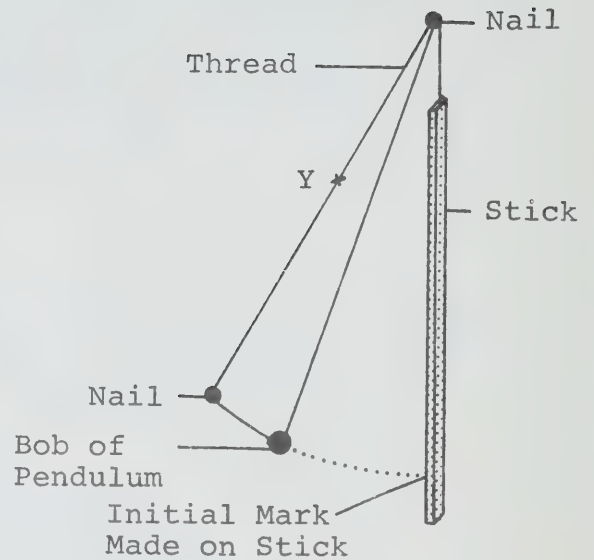
F1

A7

(E)

-

The diagram of a piece of apparatus for determining the value of the acceleration due to gravity g is shown. To use the apparatus, an initial mark is placed on the stick where the swinging bob of the pendulum would strike the stick if the stick remained stationary. The thread is burned at Y, releasing the stick and pendulum simultaneously. The pendulum then swings over and strikes the falling stick leaving another mark on the stick.



Neglecting friction, what minimum additional information is required to calculate g ?

- (A) the mass of the stick and the mass of the bob
- (B) the mass of the bob and the length of the pendulum
- (C) the length of the pendulum and the vertical height through which the bob falls
- (D) the overall length of the stick and the distance from the initial to final mark on the stick
- (E) the frequency of the pendulum and the distance from the initial to final mark on the stick

44

S17C
I.4.e

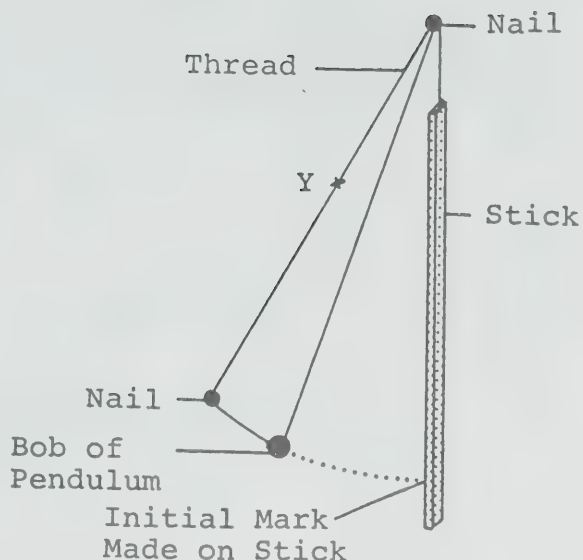
S 21

F1
A8

(C)

-

The diagram of a piece of apparatus for determining the value of the acceleration due to gravity g is shown. To use the apparatus, an initial mark is placed on the stick where the swinging bob of the pendulum would strike the stick if the stick remained stationary. The thread is burned at Y, releasing the stick and pendulum simultaneously. The pendulum then swings over and strikes the falling stick leaving another mark on the stick.



The period of the pendulum is determined to be 1.6 s. You are designing the apparatus and wish to calculate the minimum length of the stick required for the experiment. Which one of the lengths is most suitable? ($g = 10 \text{ m/s}^2$)

- (A) 0.20 m
- (B) 0.50 m
- (C) 1.0 m
- (D) 4.0 m
- (E) 15 m

45

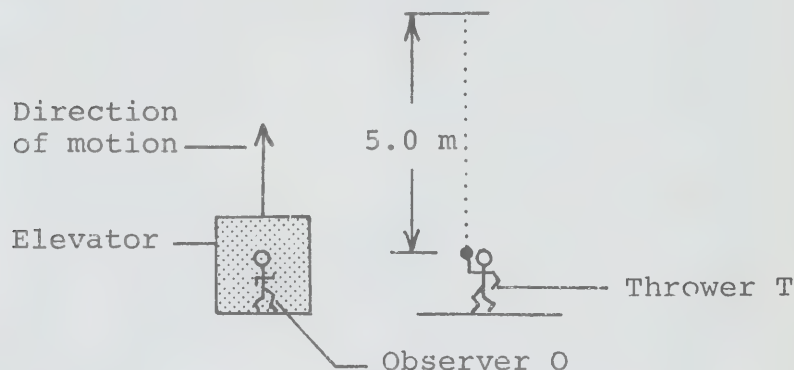
S17C
I.4

S 21

F1
A11

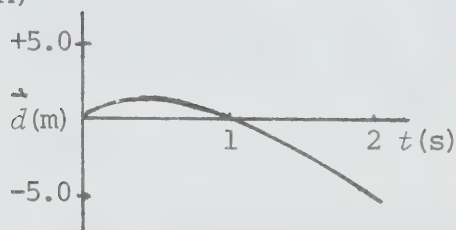
(C)

A thrower T tosses a ball upward at a velocity of 10 m/s. The ball reaches a maximum height above T of 5.0 m. An observer O, in an elevator moving upward at a constant velocity of 10 m/s, passes T at the instant the ball is thrown upward.

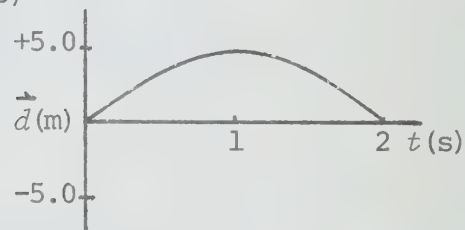


If up is positive, which displacement-time graph best represents the vertical motion of the ball with respect to O?

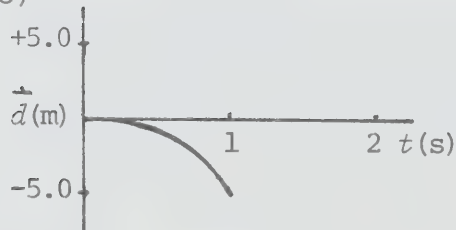
(A)



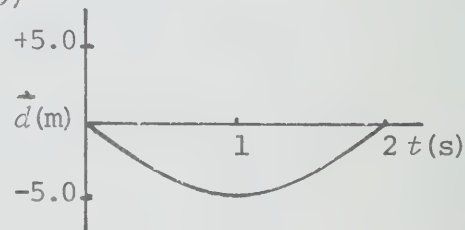
(B)



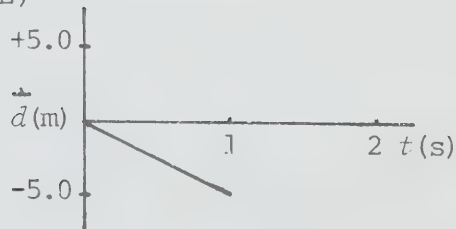
(C)



(D)



(E)



46

S17C
I.4

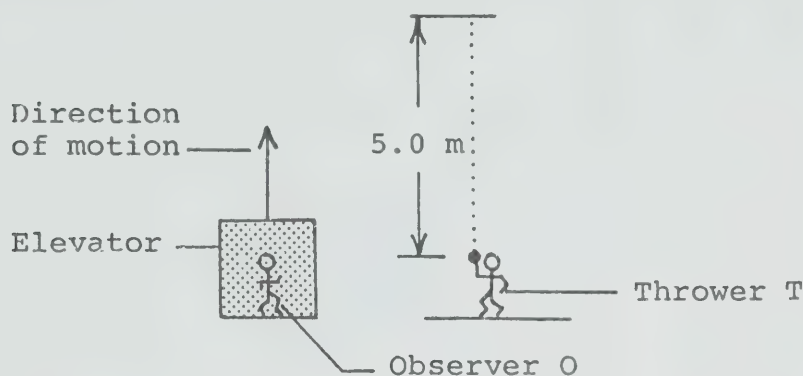
S 21

F1
A11

(E)

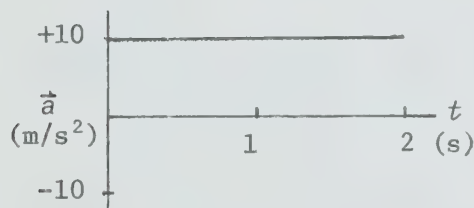
-

A thrower T tosses a ball upward at a velocity of 10 m/s. The ball reaches a maximum height above T of 5.0 m. An observer O, in an elevator moving upward at a constant velocity of 10 m/s, passes T at the instant the ball is thrown upward.

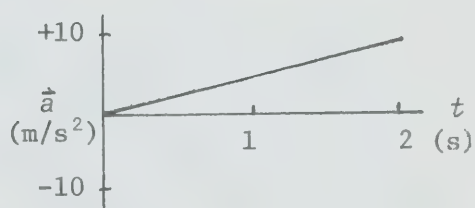


If up is positive, which acceleration-time graph best represents the motion of the ball with respect to O?

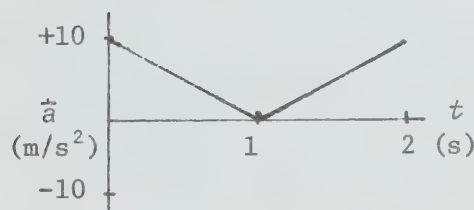
(A)



(B)



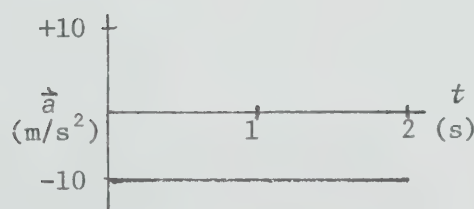
(C)



(D)



(E)



47

S17C

I.4

S 21

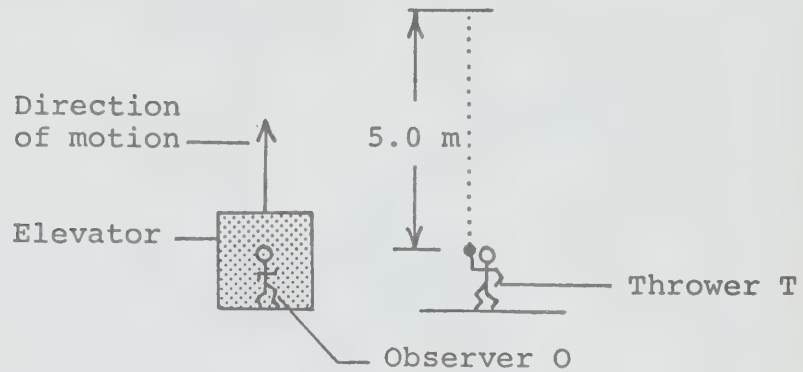
F1

All

(D)

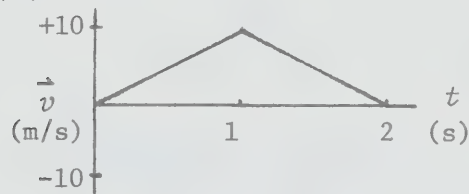
-

A thrower T tosses a ball upward at a velocity of 10 m/s. The ball reaches a maximum height above T of 5.0 m. An observer O, in an elevator moving upward at a constant velocity of 10 m/s, passes T at the instant the ball is thrown upward.

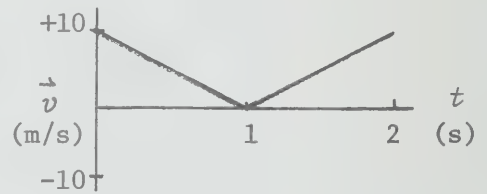


If up is positive, which velocity-time graph best represents the motion of the ball with respect to O?

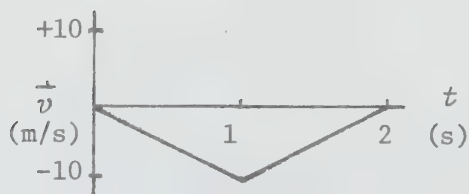
(A)



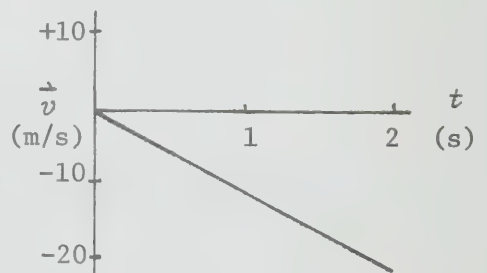
(B)



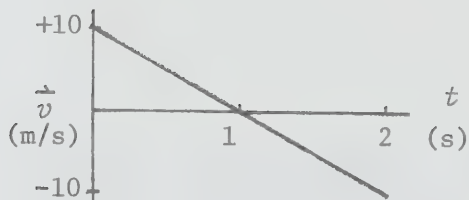
(C)



(D)



(E)



1

The graph below represents the position $\vec{x}$ versus time t for an object moving along a straight path with constant speed.

S17C

I.2.a

15

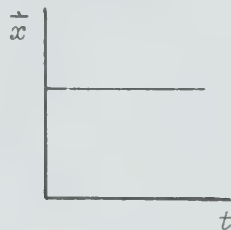
All

(B)

-
*

(A) True

(B) False



2

Three cars P, Q, R travel separately in a straight line from X to Y. The distance-time graph of each car's motion is plotted below.

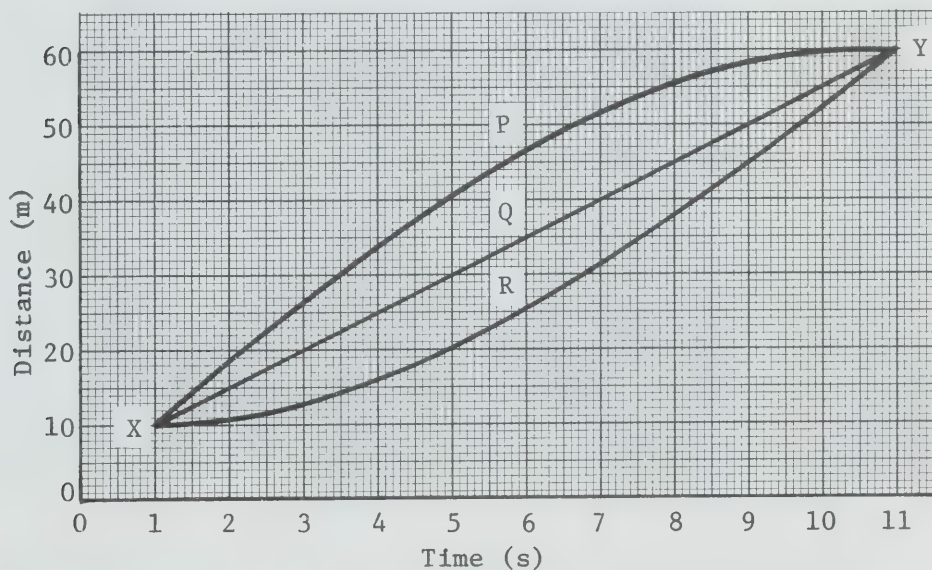
S17C

I.3.a

S 15

F1

(B)

-
**

P reaches Y in less time than either Q or R.

(A) True

(B) False

3

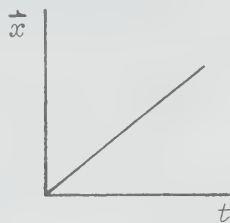
The graph below represents the position $\vec{x}$ versus time t for an object moving along a straight path with constant speed.

S17C
I.2.a

15

A11

(A)



-

*

(A) True

(B) False

4

The distance-time graph of cart Q's motion is plotted below.

S17C
I.3.a

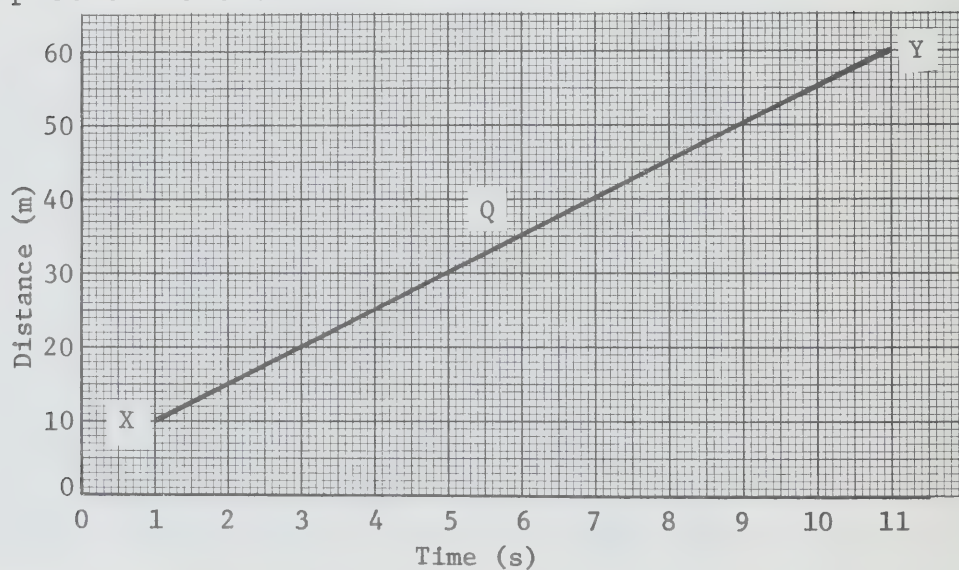
S 15

F1

(B)

-

**



Q's motion is an example of positive acceleration.

(A) True

(B) False

5

S17C
I.3.a

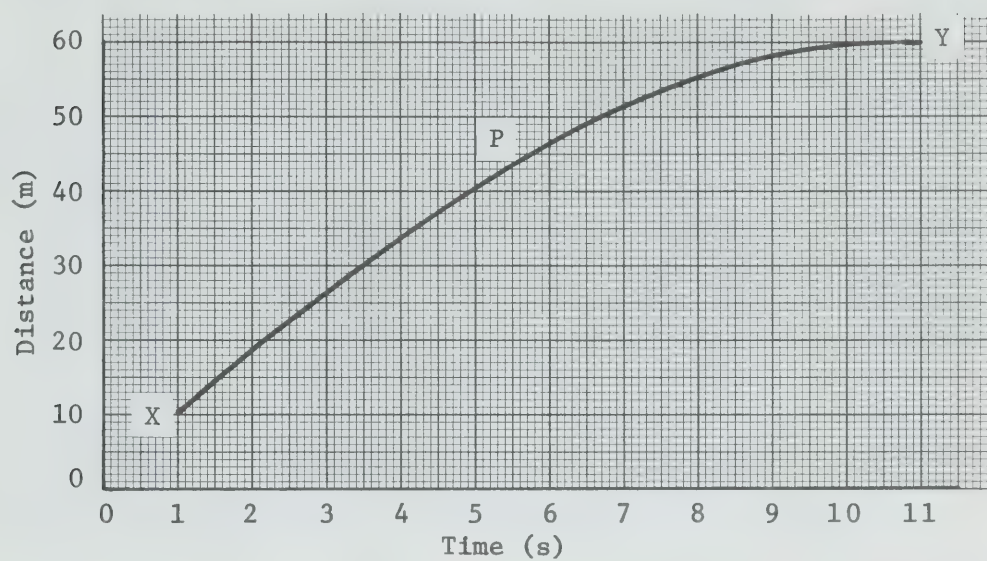
S 15

F1

(B)

-
**

The distance-time graph of cart P's motion is plotted below.



Eight seconds after P leaves X its speed is approximately 58 m/s.

(A) True

(B) False

6

S17C

I.3.a

S 15

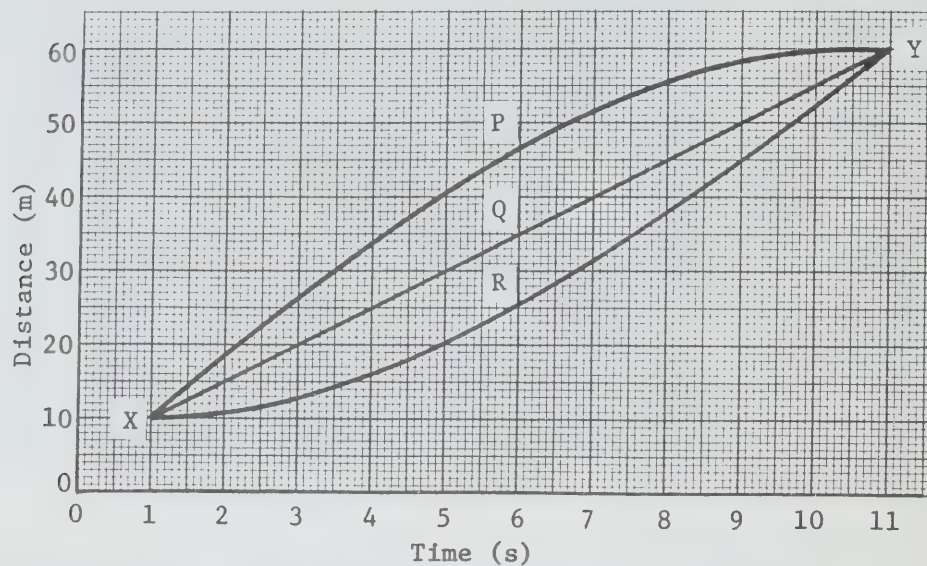
F1

(A)

-

**

Three cars P, Q, R travel separately in a straight line from X to Y. The distance-time graph of each car's motion is plotted below.



P moves more slowly than either Q or R during the last 10 m before Y.

(A) True

(B) False

7

S17C
I.3.a

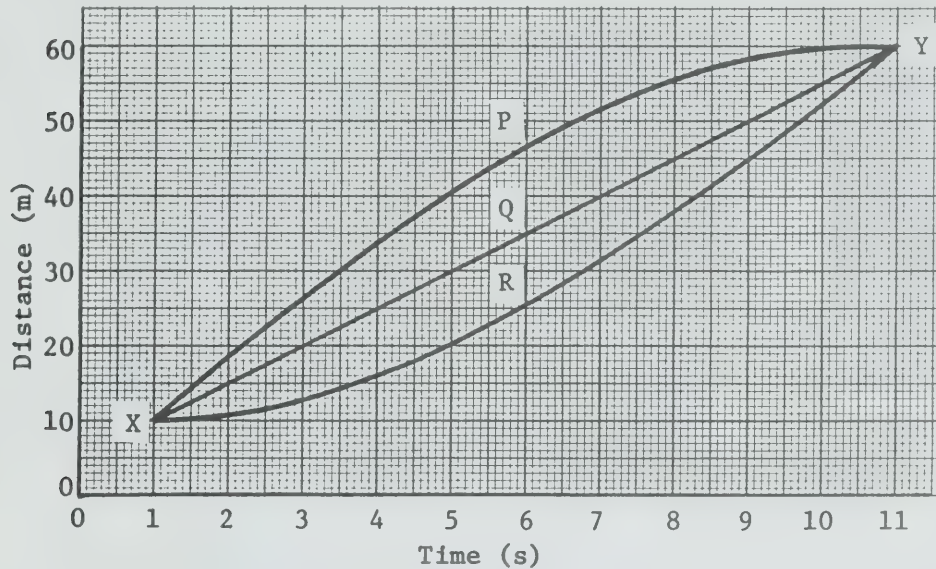
S 15

F1

(B)

-
**

Three cars P, Q, R travel separately in a straight line from X to Y. The distance-time graph of each car's motion is plotted below.



R's average speed from X to Y is less than the average speeds of either P or Q from X to Y.

- (A) True
(B) False

8

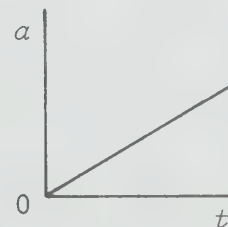
S17A
I.2.a
S17C
I.3.b16
17

A11

(B)

-
**

If a is acceleration and t is time, then this graph represents motion at constant non-zero acceleration.



- (A) True
(B) False

9

The graph below indicates constant speed.

S17C
I.3.b

17

All

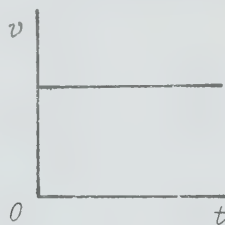
(A)

(A) True

-

**

(B) False



10

The graph below indicates constant speed.

S17C
I.3.b

17

All

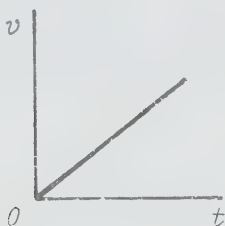
(B)

(A) True

-

*

(B) False



11

S17C
I.3.b

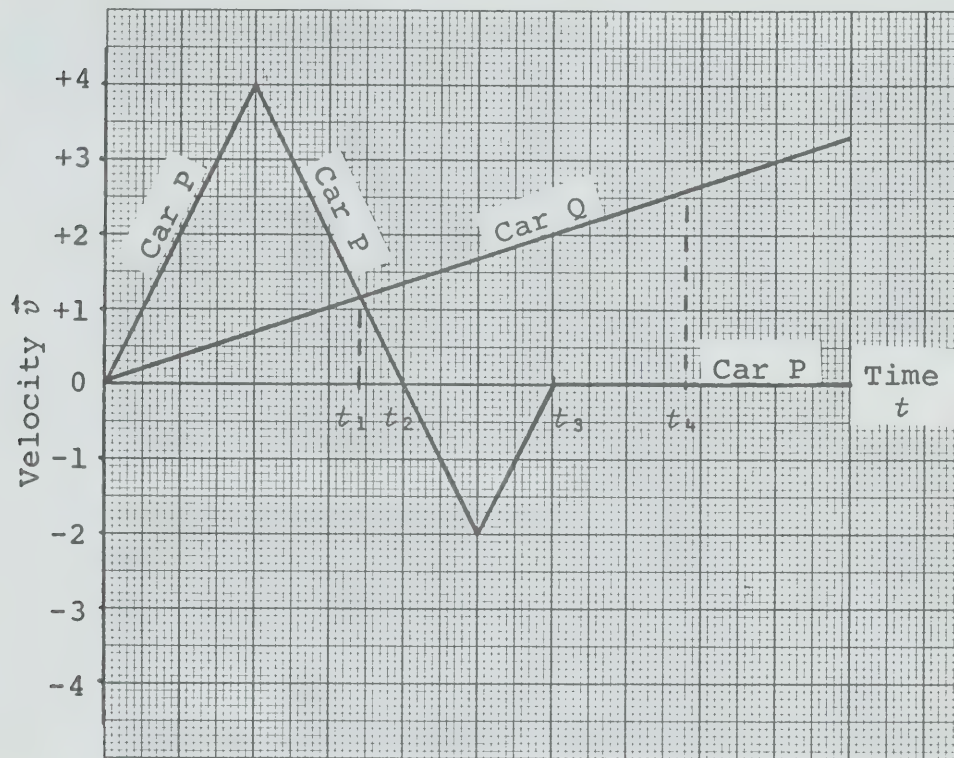
18

F1
A7

(B)

-

Car P and Car Q begin travelling simultaneously from the same point along a straight road. Velocity-time graphs of their motions are shown below.



Car Q passes Car P at time t_1 .

(A) True

(B) False

12

Car P and Car Q begin travelling simultaneously from the same point along a straight road. Velocity-time graphs of their motions are shown below.

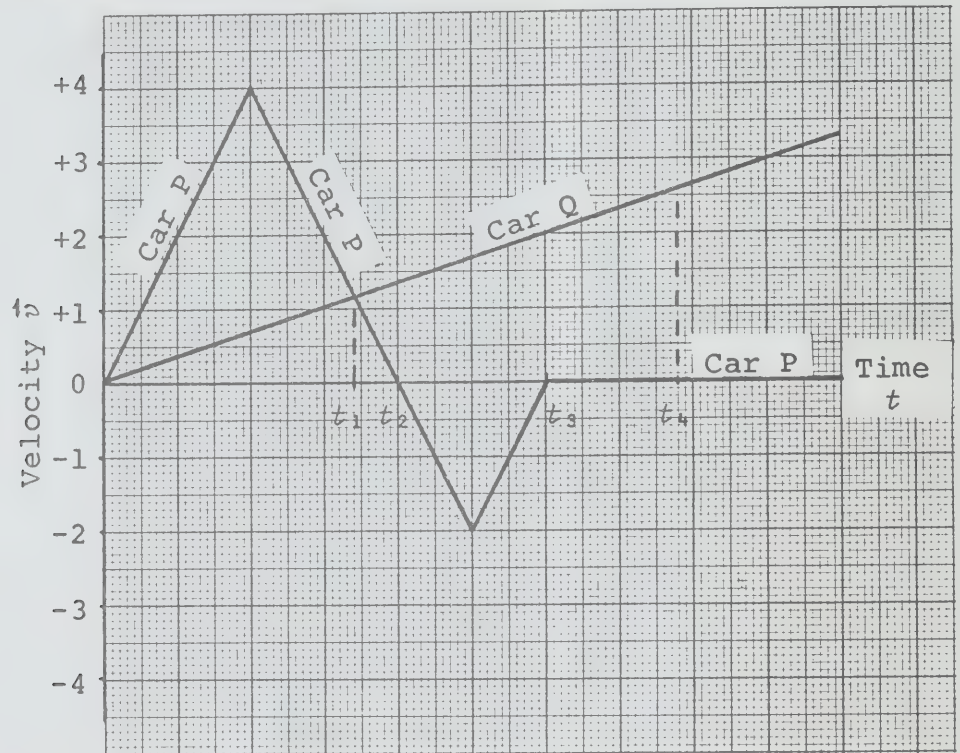
S17C
I.3.b

18

F1
A7

(B)

-



Car Q passes Car P at time t_2 .

- (A) True
(B) False

13

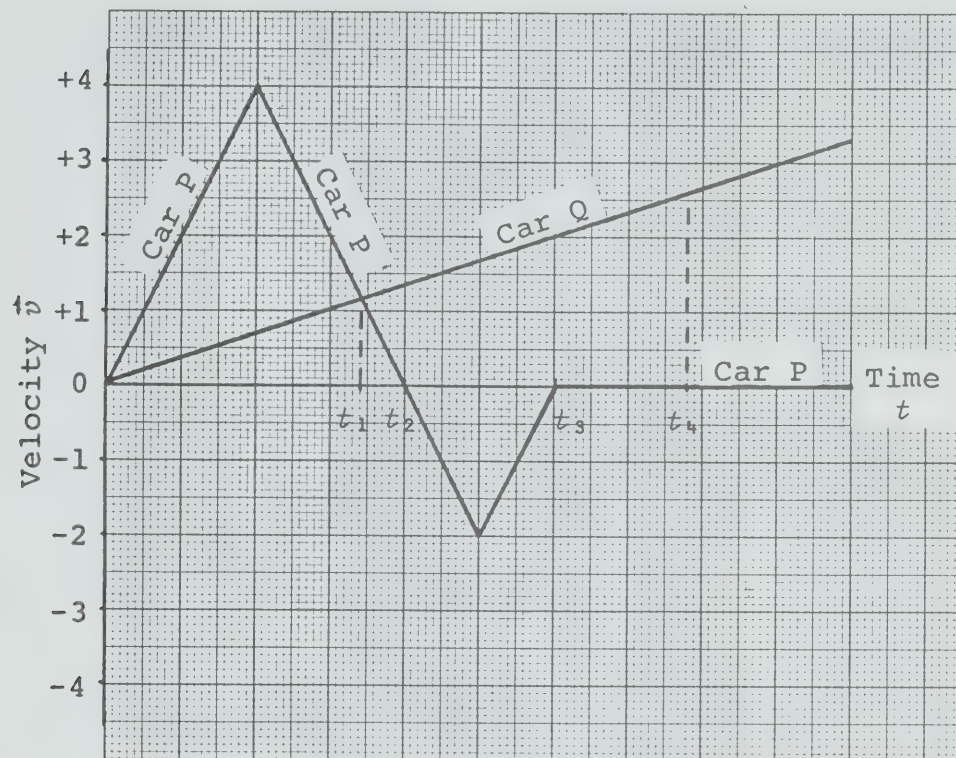
S17C
I.3.b

18

F1
A7

(A)

Car P and Car Q begin travelling simultaneously from the same point along a straight road. Velocity-time graphs of their motions are shown below.



Car Q passes Car P at time t_3 .

(A) True

(B) False

14

Car P and Car Q begin travelling simultaneously from the same point along a straight road. Velocity-time graphs of their motions are shown below.

S17C

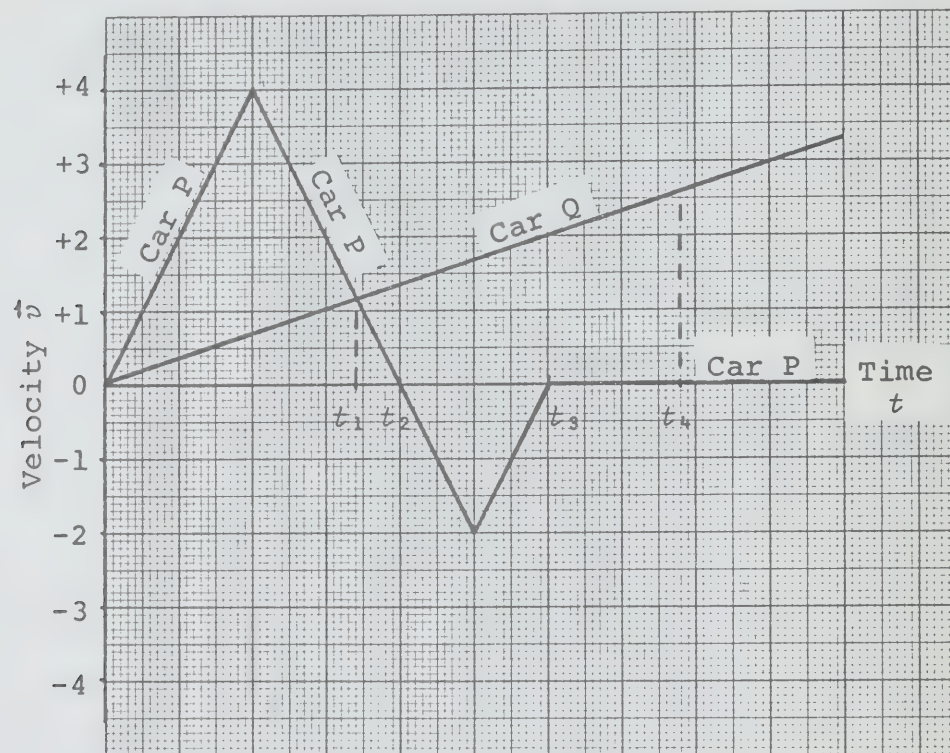
I.3.b

18

F1

A7

(B)

-
***

Car Q passes Car P at time t_4 .

- (A) True
(B) False

15

S17C

I.3.b

18

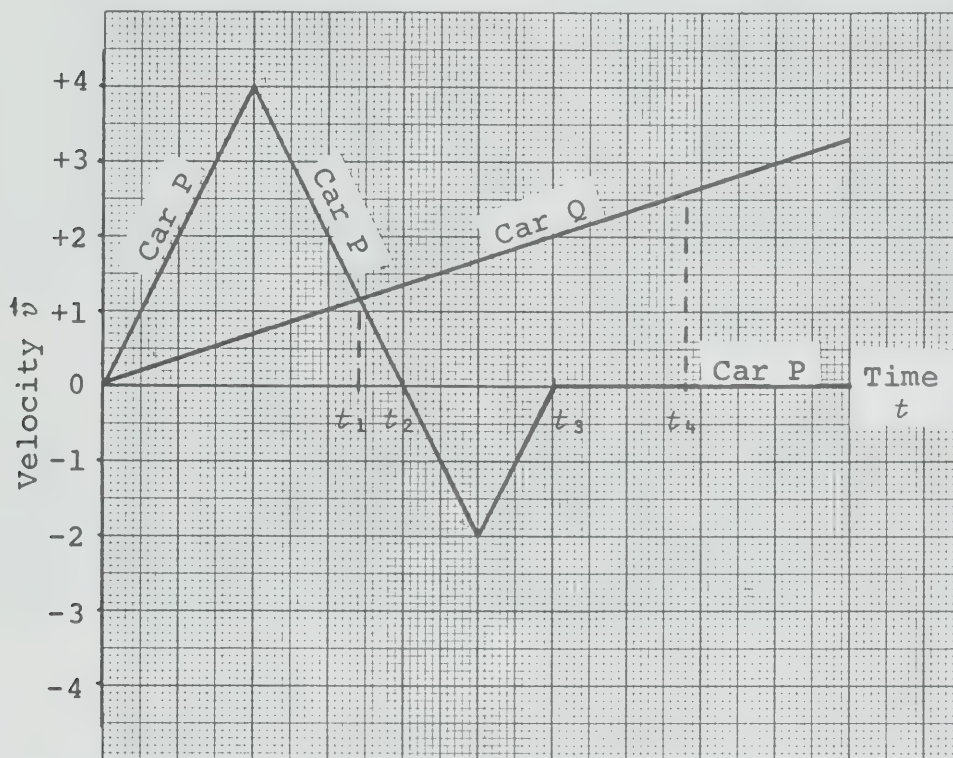
F1

A7

(B)

-

Car P and Car Q begin travelling simultaneously from the same point along a straight road. Velocity-time graphs of their motions are shown below.



Car Q does not pass Car P.

(A) True

(B) False

16

A body can have a velocity directed east and an acceleration directed north at the same time.

S17C

IV.4.f

(A) True

19

(B) False

A3

(A)

-
****17**

A car starting from rest at time t_0 ends up at position X at time t_6 . The motion of the car during this time interval is shown on the graph.

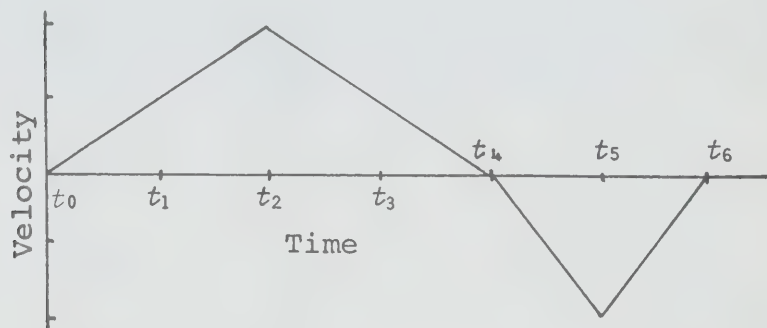
S17C

I.3.b

S 21

A11

(B)

-
***

The speed of the car increases until time t_2 , then decreases until time t_5 and then increases until time t_6 .

(A) True

(B) False

18

S17C
I.3.b

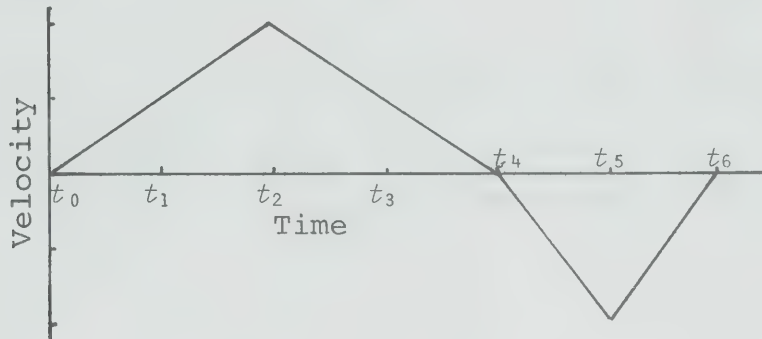
S 21

All

(B)

-

A car starting from rest at time t_0 ends up at position X at time t_6 . The motion of the car during this time interval is shown on the graph.



The car reached position X at time t_4 , stopped at time t_5 and returned to position X at time t_6 .

- (A) True
(B) False

19

S17C
I.3.b

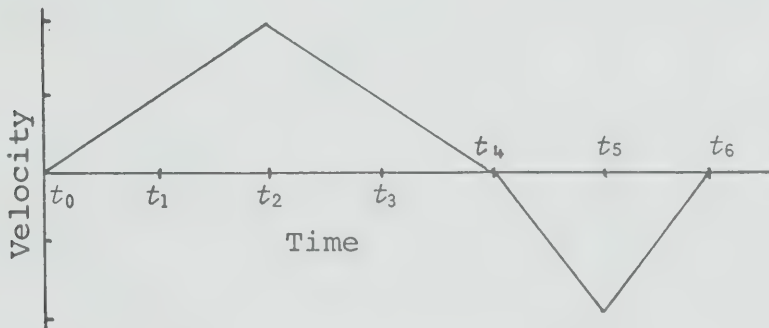
S 21

All

(A)

-

A car starting from rest at time t_0 ends up at position X at time t_6 . The motion of the car during this time interval is shown on the graph.



The car passed through position X at time t_2 , went beyond X until time t_4 and returned to position X at time t_6 .

- (A) True
(B) False

20S17C
I.3.b

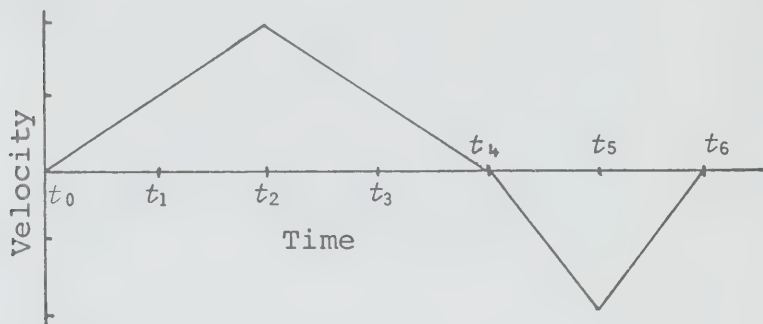
S 21

A11

(B)

-

A car starting from rest at time t_0 ends up at position X at time t_6 . The motion of the car during this time interval is shown on the graph.



The car accelerated until time t_4 , decelerated until time t_5 and accelerated until time t_6 .

- (A) True
(B) False

21S17C
I.3.b

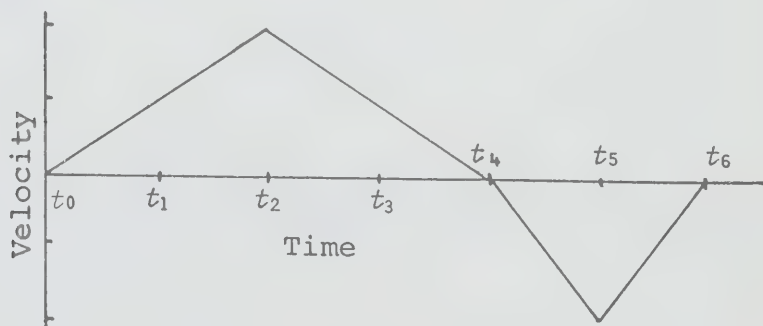
S 21

A11

(B)

-

A car starting from rest at time t_0 ends up at position X at time t_6 . The motion of the car during this time interval is shown on the graph.



The car left position X at time t_0 , went beyond position X until time t_4 and returned to position X at time t_6 .

- (A) True
(B) False

MOTION IN A PLANE

AND VECTORS

1

S17C

I.4

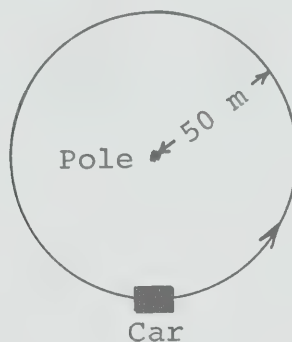
S 23

F1

(A)

-

A car is travelling counter-clockwise at 10 m/s on a circular track of radius 50 m. When the car is at the position shown below, a passenger throws a ball at a pole located at the centre of the track. The ball is thrown at 25 m/s and hits the pole.



X
Observer

What is the path of the ball as viewed by an observer on the ground if the car, at the time the ball is thrown, is directly between the observer and the pole?

(A) ↑

(B) ↖

(C) ↷

(D) ↗

(E) ↶

2

Two vectors $\vec{X}$ and $\vec{Y}$ are shown below.S17C
I.4.b

24

A3

Select the vector which most accurately represents the sum of vectors $\vec{X}$ and $\vec{Y}$.

(B)

-
*

(A)



(B)



(C)



(D)



(E)



3

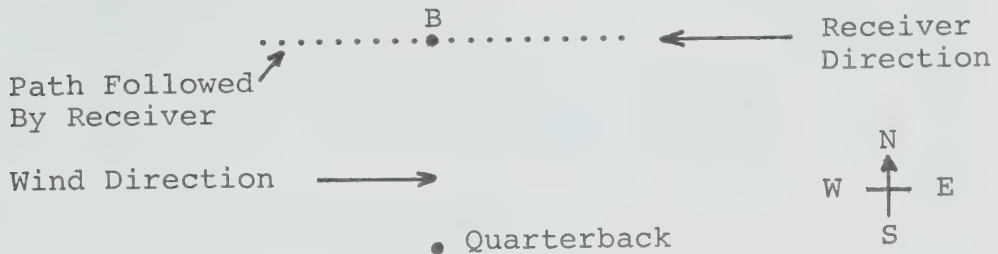
S17C
I.4.e

24

F1

(A)

A stationary quarterback throws a ball due north at 12 m/s for an intended receiver running at 6 m/s west along a path 24 m from the quarterback. Assume that a wind instantaneously gives a 1 m/s east component of velocity to the football which affects its flight.



How far east of point B should the receiver be when the quarterback releases the ball?

- (A) 14 m
- (B) 12 m
- (C) 10 m
- (D) 3.5 m
- (E) 2.0 m

4

S17C
I.4.b

24

F1

(B)

-
**

A passenger on a bus walks across the bus at 3 km/h east relative to the bus, while the bus travels south at 15 km/h.

The magnitude of the passenger's velocity relative to the road is

- (A) 18 km/h
- (B) between 15 and 18 km/h
- (C) 15 km/h
- (D) between 3 and 15 km/h
- (E) 3 km/h

5

S17C
I.4.b

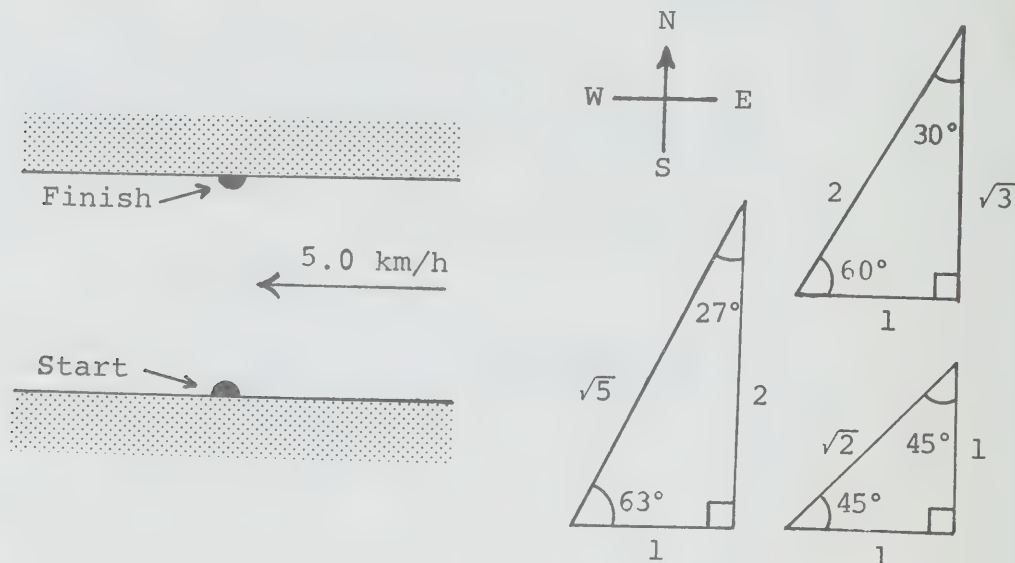
24

F1

(B)

-

A motor boat can travel at a speed of 10 km/h through still water. The boater plans to cross a river which flows at a speed of 5.0 km/h west. Diagrams showing the river, and the relative dimensions of some common triangles, are shown below.



At what angle must the boat be headed to land on the bank directly opposite the starting point?

- (A) 27° [E of N]
- (B) 30° [E of N]
- (C) 45° [E of N]
- (D) 60° [E of N]
- (E) The angle depends on the width of the river.

6

S17C
I.4.b

24

F1

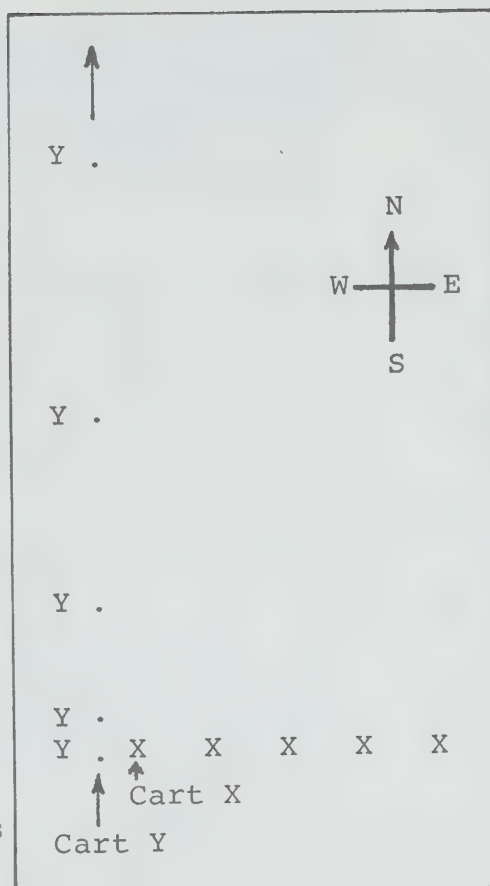
(C)

-

Two carts X and Y move as shown in the multi-flash picture at the right. It is determined that Y is accelerating north at 2 m/s^2 . X is moving east at a constant velocity of 2 m/s .

Relative to Y, X appears to be

- (A) accelerating north at 2 m/s^2
- (B) moving east at a constant velocity of 2 m/s
- (C) accelerating south at 2 m/s^2
- (D) moving south-east at a constant velocity of $\sqrt{8} \text{ m/s}$
- (E) The motion of X relative to Y cannot be determined since Newton's laws do not hold in an accelerating frame of reference.



7

S17C
I.4.b

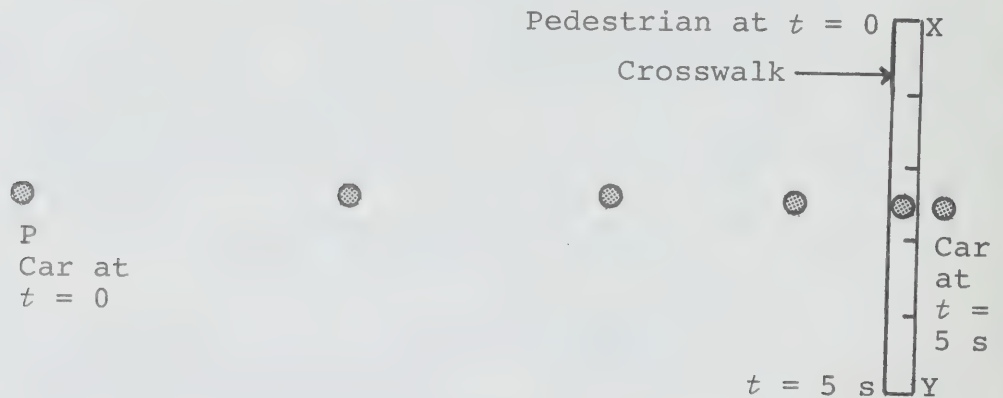
24

F1

(D)

-

A pedestrian enters a crosswalk at X and crosses to Y at a uniform speed in 5.0 s. A car driver at P sees the pedestrian enter the crosswalk and slams on the brakes. The car decelerates at a uniform rate as shown in the diagram for the same 5.0 s.



Which of the following vectors best describes the average velocity of the pedestrian between $t = 3.0$ s and $t = 4.0$ s from the driver's frame of reference?

- (A)
- (B)
- (C)
- (D)
- (E)

- 8 A thrower T tosses a ball upward at a speed of 16 m/s. An observer O, in an elevator moving upward at a constant speed of 16 m/s, passes T at the instant the ball is thrown.

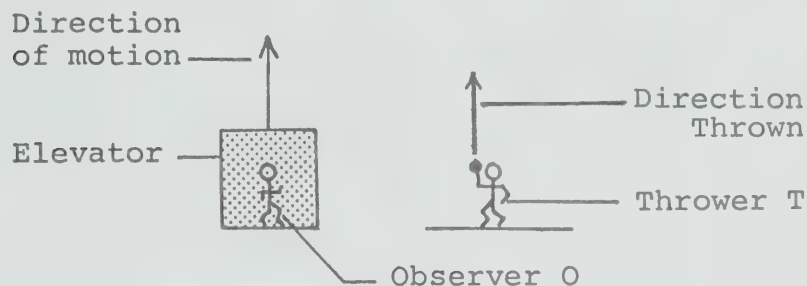
S17C
I.4.b

S 24

F1

(D)

-



Which of the following statements describes the path of the ball as seen by the observer?

- (A) The ball appears to stop for an instant at about 13 m above the thrower T.
- (B) The ball appears to decrease its speed upward and then increase its speed downward.
- (C) The downward acceleration of the ball appears to increase after it reaches its highest point.
- (D) The ball appears to increase in speed downward at a constant rate.
- (E) The ball appears closest to the observer O at a time of 1.6 s.

9

S17C
I.4.b

An experimenter and some equipment are located on a platform at the surface of the earth. The platform is supported by a machine which can give the platform various accelerations while keeping it level.
($g = 10 \text{ m/s}^2$)

S 24

F1
A8

(D)

-

Four identical guns firing identical bullets, one fired horizontally to the right, one horizontally to the left, one straight up, and one straight down, are arranged on the platform so that when the guns are fired simultaneously while the platform is not accelerating, the bullets all collide with one another at some point between the guns. The platform is now accelerated at 5.0 m/s^2 to the right, but no adjustments are made on the guns. What happens now when all guns are fired simultaneously?

- (A) The only collision is between the bullet fired upward and the one fired downward.
- (B) The only collision is between the bullet fired to the right and the one fired to the left.
- (C) The collisions described in (A) and (B) both occur, but there is no simultaneous collision of all four bullets.
- (D) All four bullets collide with one another.
- (E) None of the bullets collide.

10

Two vectors $\vec{X}$ and $\vec{Y}$ are shown below.S17C
I.4.b

25

A3

(A)

Select the vector which most accurately represents the vector difference $\vec{X} - \vec{Y}$.-
**

(A)



(B)



(C)



(D)



(E)



11

Two vectors $\vec{X}$ and $\vec{Y}$ are shown below.S17C
I.4.b

25



A3

(C)

Select the vector which most accurately represents the vector difference $\vec{Y} - \vec{X}$.-
**

(A)



(B)



(C)



(D)



(E)



12

S17C
I.4.c

25

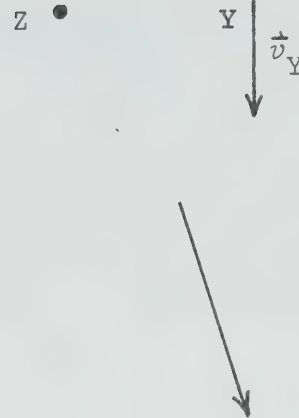
F1

A7

(E)

-

Ship Y, located due east of ship Z, is travelling directly south at 20 km/h. The velocity vector of ship Y, with reference to the earth, is shown.



Which of the following is the most accurate velocity vector for ship Z with reference to the earth?

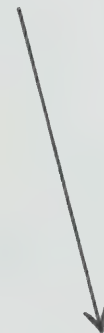
(A)



(B)



(C)



(D)



(E)



13

S17C
I.4.c

A pilot wishes to travel north in an airplane with an air speed of 300 km/h. The wind is blowing from the east at 20 km/h.

The heading that the plane should fly is

25

A3

F1

(C)

-
**

(A) slightly west of north.

(B) exactly north.

(C) slightly east of north.

(D) slightly north of east.

(E) impossible to determine with the data given.

14

S17C
I.4.c

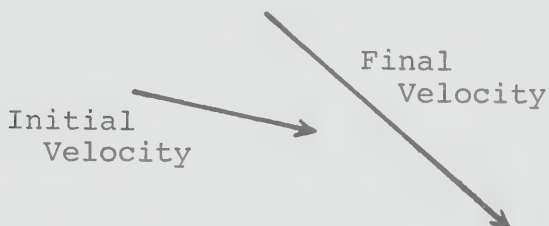
The initial and final velocity vectors for a short time interval Δt are shown below for an object moving in a curved path. Assume that there is no friction.

S 25

F1

A2

(D)

-
**

Which of the following statements about the object's motion is correct?

(A) The speed and velocity are both constant.

(B) The speed is constant and the velocity is increasing.

(C) The speed is constant and the velocity is decreasing.

(D) The speed is increasing and the velocity is changing.

(E) The speed is decreasing and the velocity is changing.

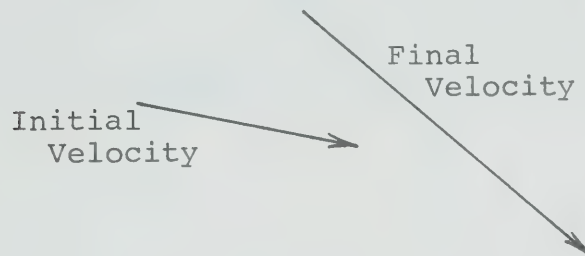
- 15** The initial and final velocity vectors for a short time interval Δt are shown below for an object moving in a curved path.

S17C
I.4.c

S 25

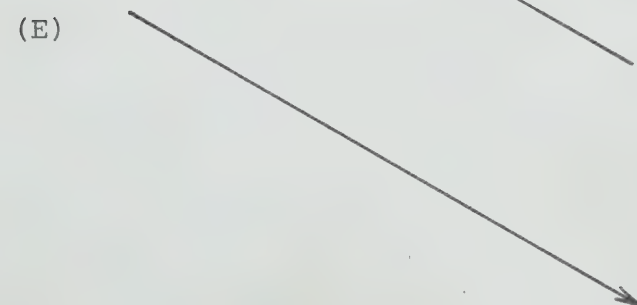
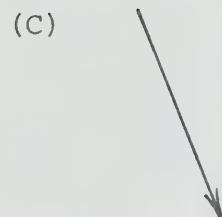
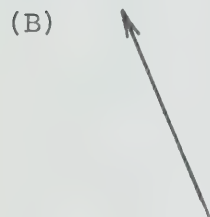
F1
A2
A7

(C)



-

Which of the following vectors represents the change in velocity of the object?



16S17C
I.4.c

Sets of three vectors are drawn to show an object's velocity separated by equal time intervals. Assume that the left hand vector in each set corresponds with the earliest time.

S 27

Which set below could represent an object after it is thrown upward on the earth?

A11

A3

(C)

-
*

(A)



(B)



(C)



(D)



(E)



17

S17C

I.4.c

S 27

A11

A3

(E)

-

**

Sets of three vectors are drawn to show an object's velocity separated by equal time intervals. Assume that the left hand vector in each set corresponds with the earliest time.

Which set below could represent an object moving at a constant velocity?

(A)



(B)



(C)



(D)



(E)



18S17C
I.4.d

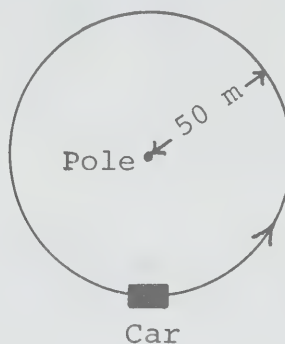
S 27

F1

(C)

-

A car is travelling counter-clockwise at 10 m/s on a circular track of radius 50 m. When the car is at the position shown below, a passenger throws a ball at a pole located at the centre of the track. The ball is thrown at 25 m/s and hits the pole.



Which arrow most closely indicates the path of the ball as seen by the passenger?

- (A)
- (B)
- (C)
- (D)
- (E)

19 A velocity vector of 240 m/s has an angle of 47° to the horizontal.

S17C

I.4.d Its horizontal component is

28 (A) $240 \sin 47^\circ \text{ m/s}$ A3 (B) $240 \cos 47^\circ \text{ m/s}$ (B) (C) 240 m/s - (D) $240 \cos 43^\circ \text{ m/s}$

**

(E) $240 \tan 47^\circ \text{ m/s}$

20 A cannon fires a shell at 500 m/s at an angle of 30° above the horizontal.

S17C

I.4.d The horizontal component of the velocity is

28 (A) $\frac{500 \sqrt{3}}{\sqrt{2}} \text{ m/s}$

A3

F1

(B) 250 m/s (E) (C) $500 \sqrt{3} \text{ m/s}$

-

**

(D) $\frac{1000}{\sqrt{3}} \text{ m/s}$ (E) $250 \sqrt{3} \text{ m/s}$ Trigonometric Relationships

$$\text{Sine } 30^\circ = \frac{1}{2}$$

$$\text{Cos } 30^\circ = \frac{\sqrt{3}}{2}$$

$$\text{Tan } 30^\circ = \frac{1}{\sqrt{3}}$$

21

A cannon fires a shell at 500 m/s at an angle of 30° above the horizontal.

S17C

I.4.d

The horizontal component of the velocity is

28

(A) 250 m/s

A3

(B) 433 m/s

F1

(C) 577 m/s

(B)

(D) 612 m/s

-

**

(E) 866 m/s

22

Sets of three vectors are drawn to show an object's velocity separated by equal time intervals. Assume that the left hand vector in each set corresponds with the earliest time.

S17C

I.4.e

S 29

Which set below could represent an object moving upward with a constant acceleration?

A11

A3

(A)

(A)

-

**

(B)

(C)

(D)

(E)



23

Which of the following examples is not an example of accelerated motion? (Assume that friction can be ignored.)

S17C
I.4.e

S 29

A2
A3

(E)

-
**

- (A) an object moving in a circle at constant speed
- (B) the vertical component of the velocity of a projectile
- (C) the motion of a simple pendulum
- (D) the earth in orbit about the sun
- (E) the horizontal component of the velocity of a projectile

24

Sets of three vectors are drawn to show an object's velocity separated by equal time intervals. Assume that the left hand vector in each set corresponds with the earliest time.

S17C
I.4.c

S 29

A11
A3

(E)

-
**

Which set below could represent an object with zero acceleration?

(A)



(B)



(C)



(D)



(E)



25S17C
I.4.e

SS 29

Identical guns fire identical bullets horizontally with the same speed from the same height above level planes on the earth and the moon. The acceleration due to gravity on the earth is about six times that on the moon. Assume that air resistance is negligible.

F1

Consider the following statements about the motion of the bullets.

(B)

-
**

- I. The horizontal distance covered before the bullet hits the ground is greater on the moon than on the earth.
- II. The time to fall to the ground is less on the earth than on the moon.
- III. The instantaneous velocity of the bullet just before impact is the same on the moon as on the earth.

Which of the above statements is/are true?

- (A) III only
- (B) I and II only
- (C) I and III only
- (D) II and III only
- (E) I, II and III

26S17C
I.4.f

30

A8

(A)

-

An object travels in a circular path at constant speed.

Its average acceleration over one full revolution is

- (A) zero
- (B) directed towards the centre of the circle
- (C) directed away from the centre of the circle
- (D) directed forward along a tangent to the circle
- (E) directed forward along the arc of the circle

27

S17C
III.1.d

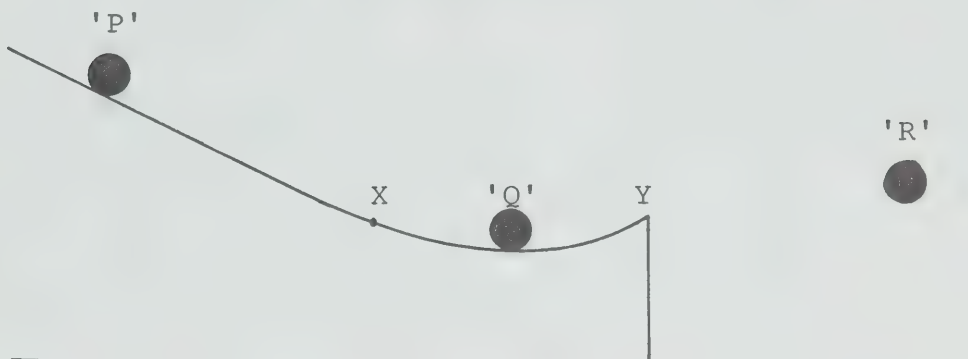
30

F1

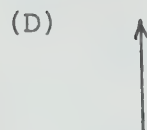
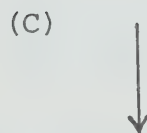
(D)

-

A steel ball is placed at the top of the ramp shown and released. The ramp is curved from X to Y. Neglect all friction.



The acceleration of the ball at position 'Q' is best represented by the vector



(E) zero

28

An object travels in a circular path at constant speed.

S17C

I.4.f

Its instantaneous acceleration is

30

(A) zero

A8

(B) directed towards the centre of the circle

(B)

(C) directed away from the centre of the circle

-

(D) directed forward along a tangent to the circle

**

(E) directed forward along the arc of the circle

29

The diagram shows an object tied to the end of a string moving counterclockwise in a circle at constant speed on a frictionless level surface. The distance travelled by the object in moving from W to X is 25 m. It takes the object 20 s to complete one revolution.

S17C

I.4.f

S 30

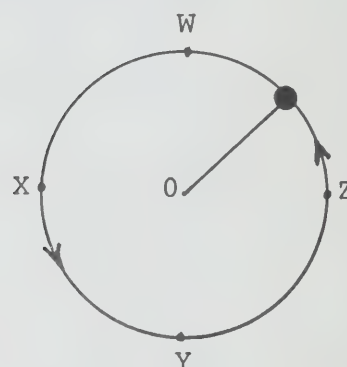
A2

A5

(C)

-

**



During the motion, the magnitude of the instantaneous acceleration is

(A) increasing

(B) decreasing

(C) constant

(D) zero

(E) greatest at Y

30S17C
III.1.d

An object on a frictionless surface is subjected to a force of constant magnitude and varying direction. The force is always perpendicular to the instantaneous velocity.

S 30

Therefore the object

A3

(A) moves in a circle with zero acceleration in the direction of motion

(A)

(B) moves in a spiral with constant acceleration

-

(C) moves in a circle with increasing speed

(D) moves in a spiral with constant speed

(E) moves in a circle with an acceleration which is constant in both magnitude and direction

31S17C
III.1.d

An object on a frictionless surface is subjected to a force of constant magnitude and varying direction. The force is always perpendicular to the instantaneous velocity.

S 30

Therefore the object moves in a circle

A3

(A) with zero acceleration in the direction of motion

(A)

(B) with constant non-zero acceleration in the direction of motion

-

(C) with zero acceleration towards the centre

(D) with acceleration towards the centre which is constant in magnitude and in direction

(E) with acceleration toward the centre which is changing in both magnitude and direction

32

S17C
I.4.f

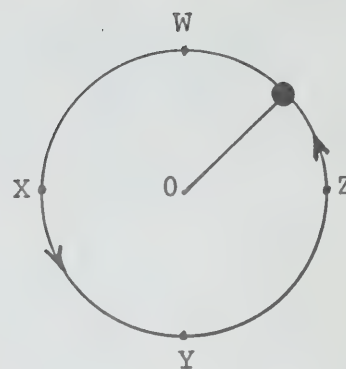
S 30

A3
A1
A11

(B)

-
**

The diagram shows an object tied to the end of a string moving counterclockwise in a circle at constant speed on a frictionless level surface. The distance travelled by the object in moving from W to X is 25 m. It takes the object 20 s to complete one revolution.



What is the direction of the acceleration of the object when at Y?

(A)



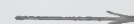
(B)



(C)



(D)



(E)



33

Sets of three vectors are drawn to show an object's velocity separated by equal time intervals. Assume that the left hand vector of each set corresponds to the earliest time.

S17C
I.4.f

S 30

Which set below could represent an object moving in a circle at constant speed? (Assume no more than one rotation.)

A11
A3

(B)

—

(A)



(B)



(C)



(D)



(E)



34

S17C
I.4.c

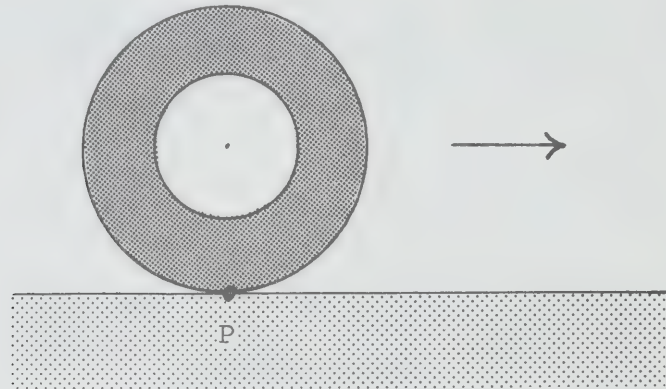
S 30

F1

(E)

-

A wheel on a car is shown moving along a horizontal road. The car's velocity is represented by the vector $\longrightarrow$ and P is the point of contact of the wheel with the road.



The vector best representing the instantaneous velocity of point P relative to the road is

(A) $\longrightarrow$ (B) $\longleftarrow$ (C) $\uparrow$ (D) $\nearrow$

(E) zero

35

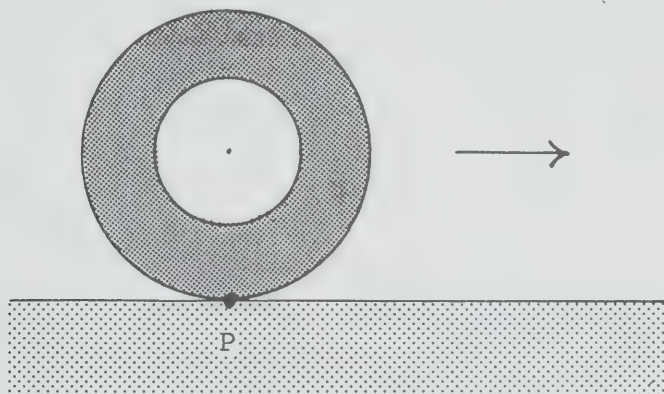
S17C
I.4.c

A wheel on a car is shown moving along a horizontal road. The car's velocity is represented by the vector $\longrightarrow$ and P is the point of contact of the wheel with the road.

S 30

F1

(C)



The vector best representing the instantaneous acceleration of point P is

(A) $\longrightarrow$ (B) $\longleftarrow$ (C) $\uparrow$ (D) $\nearrow$

(E) zero

36

A car travels at a constant speed of 50 km/h from X to Y along a spiral racetrack as shown.

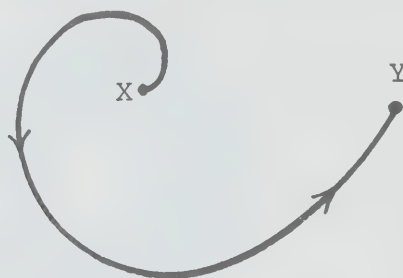
S17C
I.4.f

S 30

F1

(B)

-



The instantaneous acceleration vector at all times

- (A) has a constant magnitude and is perpendicular to the instantaneous velocity vector.
- (B) decreases in magnitude and is perpendicular to the instantaneous velocity vector.
- (C) increases in magnitude and is directed at an angle of less than 90° to the instantaneous velocity vector.
- (D) has a constant magnitude and is directed at an angle less than 90° to the instantaneous velocity vector.
- (E) has a constant magnitude and is directed at an angle greater than 90° to the instantaneous velocity vector.

37 The stroboscope photograph shows a particle travelling part way around a circle.

S17C
I.4.f

S 30

F1
A3

(B)

—



The instantaneous acceleration vector at X is best represented by

(A)

(B)

(C)

(D)

(E)

38S17C
I.4.e

SS 30

F1
A10

(C)

-
**

A subway train is moving at a constant velocity to the left. A rider on the train throws a ball vertically into the air and catches it.

Which path would the ball take, as seen by an observer standing on the stationary subway platform?

(A)



(B)



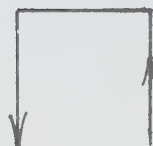
(C)



(D)



(E)



- 1 This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} + \vec{B} = \vec{C}$$

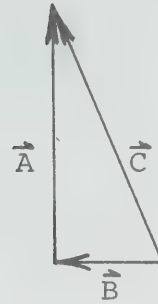
24

A11

(A)

- (A) True
(B) False

-
**



- 2 This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} + \vec{B} = \vec{C}$$

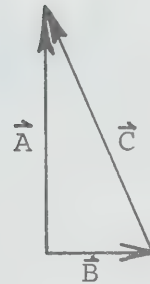
24

A11

(B)

- (A) True
(B) False

-
*



- 3 This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} + \vec{B} = \vec{C}$$

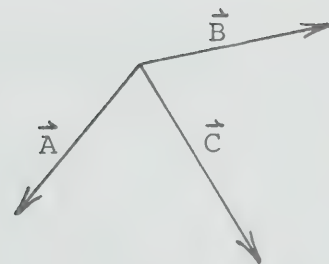
24

A11

(B)

- (A) True
(B) False

-
*



4

This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{B} + \vec{A} = \vec{C}$$

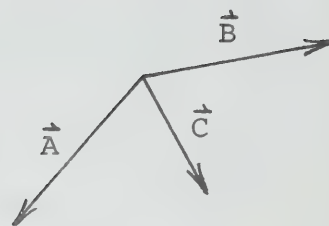
24

(A) True

A11

(B) False

(A)

-
**

5

This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} + \vec{B} = \vec{C}$$

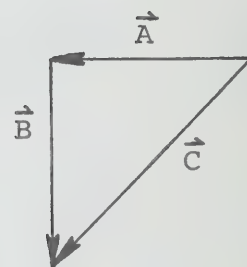
24

(A) True

A11

(B) False

(A)

-
*

6

This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} = \vec{B} + \vec{C}$$

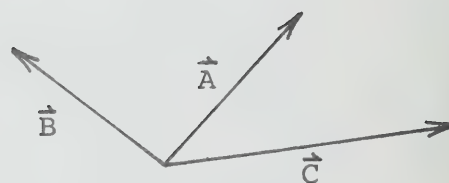
24

(A) True

A11

(B) False

(A)

-
**

7 This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} + \vec{B} = \vec{C}$$

24

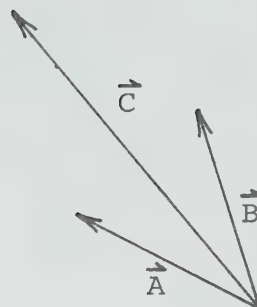
(A) True

A11

(B) False

(A)

-
**



8 This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} + \vec{B} = \vec{C}$$

24

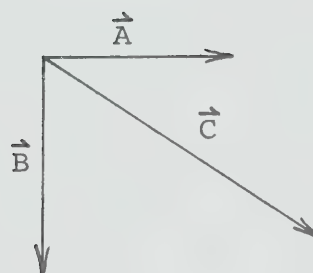
(A) True

A11

(B) False

(B)

-
**



9 This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} + \vec{B} = \vec{C}$$

24

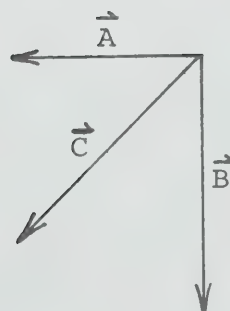
(A) True

A11

(B) False

(B)

-
**



10

This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} + \vec{B} = \vec{C}$$

24

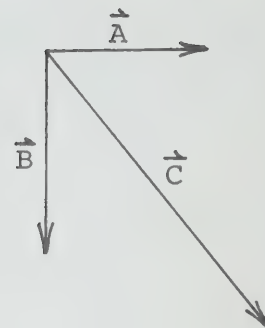
(A) True

A11

(B) False

(B)

-
*

**11**

This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} + \vec{B} = \vec{C}$$

24

31

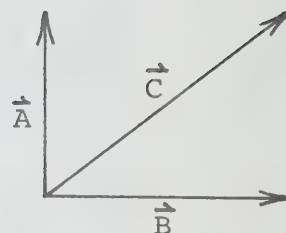
(A) True

A11

(B) False

(A)

-
**

**12**

This vector diagram is represented correctly by the equation

S17C
I.4.b

$$\vec{A} + \vec{B} = \vec{C}$$

24

31

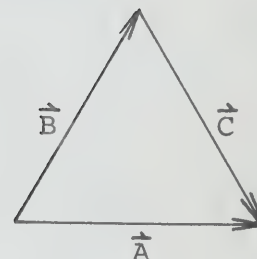
(A) True

A11

(B) False

(B)

-
*



13S17C
I.4.b

This vector diagram is represented correctly by the equation

$$\vec{A} - \vec{B} = \vec{C}$$

25

(A) True

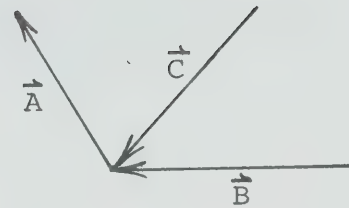
A11

(B) False

(B)

-

**

**14**S17C
I.4.b

This vector diagram is represented correctly by the equation

$$\vec{B} - \vec{C} = \vec{A}$$

25

(A) True

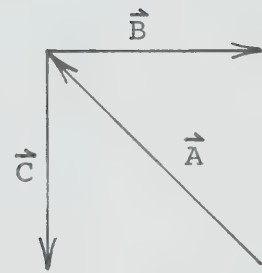
F1

(B) False

(B)

-

**

**15**S17C
I.4.b

This vector diagram is represented correctly by the equation

$$\vec{C} - \vec{A} = \vec{B}$$

25

(A) True

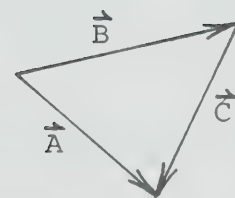
F1

(B) False

(B)

-

**



16S17C
I.4.b

25

A11

(A)

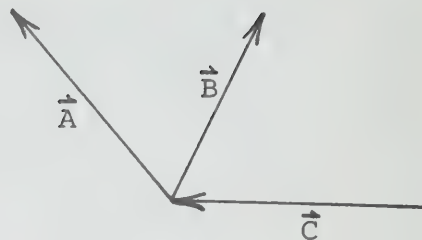
-
**

This vector diagram is represented correctly by the equation

$$\vec{B} = \vec{A} - \vec{C}$$

(A) True

(B) False

**17**S17C
I.4.b

25

A11

(A)

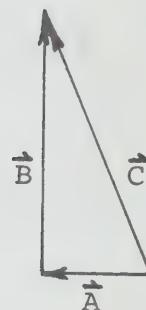
-
**

This vector diagram is represented correctly by the equation

$$\vec{A} + \vec{B} = \vec{C}$$

(A) True

(B) False

**18**S17C
I.4.b

25

A11

(B)

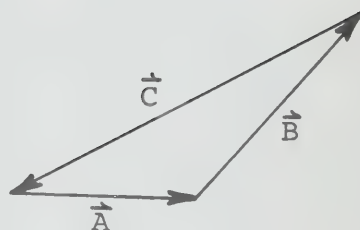
-
*

This vector diagram is represented correctly by the equation

$$\vec{B} - \vec{A} = \vec{C}$$

(A) True

(B) False



19S17C
III.4.a

A projectile is fired at an angle of 45° above the horizontal. Assume that air resistance is not significant.

29
51

While the projectile is in flight, the impulse applied to it by gravity is equal to its change in momentum.

A3
A8
A10

- (A) True
(B) False

(A)

-
****20**S17C
III.2.b

A projectile is fired at an angle of 45° above the horizontal. Assume that air resistance is not significant.

29
51

While the projectile is in flight, the horizontal component of the velocity remains constant.

A3
A8
A10

- (A) True
(B) False

(A)

-
****21**S17C
III.2.b

A projectile is fired at an angle of 45° above the horizontal. Assume that air resistance is not significant.

29
51

While the projectile is in flight, the acceleration remains constant.

A3
A8
A10

- (A) True
(B) False

(A)

-

22

A projectile is fired at an angle of 45° above the horizontal. Assume that air resistance is not significant.

S17C

III.5.a

The kinetic energy of the projectile is zero at maximum height.

29

51

(A) True

A3

A8

(B) False

A10

(B)

-

23

An object travels in a circular path at constant speed. Its average acceleration over one full revolution is zero.

S17C

I.4.f

(A) True

30

(B) False

A8

(A)

-

24

An object travels in a circular path at constant speed. Its average acceleration over one full revolution is directed towards the centre of the circle.

S17C

I.4.f

30

(A) True

A8

(B) False

(B)

-

25 An object travels in a circular path at constant speed. Its average acceleration over one full revolution is directed away from the centre of the circle.

S17C
I.4.f

30 (A) True

A8 (B) False

(B)

-

26 An object travels in a circular path at constant speed. Its average acceleration over one full revolution is directed forward along a tangent to the circle.

S17C
I.4.f

30 (A) True

A8 (B) False

(B)

-

27 An object travels in a circular path at constant speed. Its average acceleration over one full revolution is directed forward along the arc of the circle.

S17C
I.4.f

30 (A) True

A8 (B) False

(B)

-

28

An object travels in a circular path at constant speed. Its instantaneous acceleration is zero.

S17C
I.4.f

(A) True

30

(B) False

A8

(B)

-
**

29

An object travels in a circular path at constant speed. Its instantaneous acceleration is directed towards the centre of the circle.

S17C
I.4.f

(A) True

30

(B) False

A8

(A)

-
**

30

An object travels in a circular path at constant speed. Its instantaneous acceleration is directed away from the centre of the circle.

S17C
I.4.f

(A) True

30

(B) False

A8

(B)

-
**

31 An object travels in a circular path at constant speed. Its instantaneous acceleration is directed forward along a tangent to the circle.

S17C
I.4.f

(A) True

30

(B) False

A8

(B)

-

**

32 An object travels in a circular path at constant speed. Its instantaneous acceleration is directed forward along the arc of the circle.

S17C
I.4.f

(A) True

30

(B) False

A8

(B)

-

**

33 A body is moving in a circle with steadily increasing speed. The instantaneous acceleration of the body is directed to the centre of the circle.

S17C
I.4.f

(A) True

30

(B) False

F1
A11

(B)

-

D Y N A M I C S

FORCE AND

NEWTON'S LAWS

- 1** An object is placed on an inclined plane. There is a component of the force of gravity acting on the object in a direction parallel to the plane.
- S17A
I.2.c
S17C
III.1.d
- If the inclined plane is made steeper, that component
- (A) remains the same
 - (B) always increases
 - (C) always decreases
 - (B) (D) may either increase or decrease depending on the initial angle of inclination
 - ** (E) may either increase or decrease depending on the roughness of the surfaces

- 2** A 3 kg sphere is released on a smooth frictionless plane which is inclined 30° to the horizontal.
($g = 10 \text{ m/s}^2$)
- S17C
III.1.d
- The unbalanced force on the sphere is closest to
- 31 (A) zero
 - F1 (B) 10 N
 - A3 (C) 15 N
 - (C) (D) 26 N
 - *** (E) 30 N

3

A 3 kg sphere is released on a smooth frictionless plane which is inclined 30° to the horizontal.
($g = 10 \text{ m/s}^2$)

S17C

III.1.d

31

The force exerted by the plane on the sphere is closest to

F1

A3

(D)

-

(A) zero

(B) 10 N

(C) 15 N

(D) 26 N

(E) 30 N

4

The diagram shows an object tied to the end of a string moving counterclockwise in a circle at constant speed on a frictionless level surface. The distance travelled by the object in moving from W to X is 25 m. It takes the object 20 s to complete one revolution.

S17C

I.4.c

32

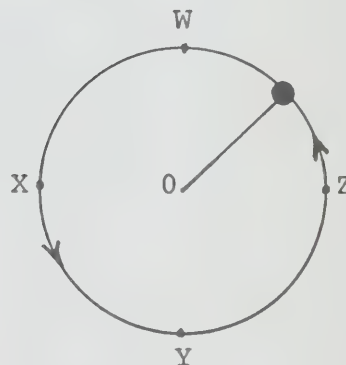
A8

A5

(D)

-

**



If the string breaks when the object is at Z, the object will

- (A) move outward from the centre of the circle at constant speed.
- (B) move inward toward the centre of the circle at constant speed.
- (C) continue to move in a circle at constant speed.
- (D) move along the tangent to the circle at point Z with constant speed.
- (E) move along the tangent to the circle at point Z with decreasing speed.

5

S17C
III.1.a

32

F1

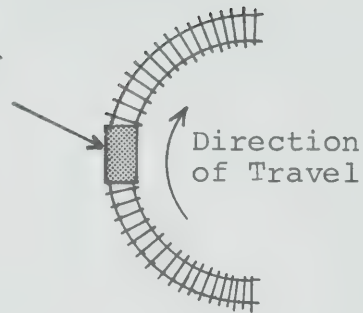
(D)

-

**

A train is rounding a sharp curve to the right at 65 km/h. The last car is a flat car on which a man is standing at the back edge. He throws a ball straight up in the air with respect to the flat car. Assume air friction can be neglected.

Flatcar
of
Train



The ball will land

- (A) in the man's hand.
- (B) between the tracks exactly at the spot over which the man was standing when he released the ball.
- (C) between the tracks ahead of the original position from which it was thrown.
- (D) to the left of the tracks ahead of the original position from which it was thrown.
- (E) to the right of the tracks ahead of the original position from which it was thrown.

6

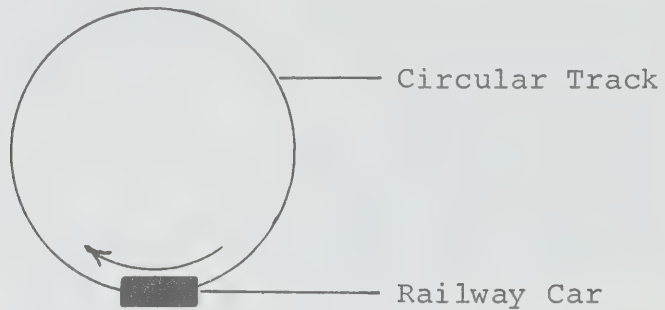
S17C
III.1.a

A railway car is moving at a constant speed around a circular track. A passenger, facing forward in the middle of the car, throws a ball straight up with respect to the floor of the car.

S 32

F1

(D)

-
***

Where will the ball land with reference to the passenger if friction is ignored?

- (A) directly behind the passenger
- (B) directly in front of the passenger
- (C) into the hands of the passenger
- (D) behind and to the left of the passenger
- (E) directly opposite and to the left of the passenger

7

S17C

III.1.a

S 32

S 33

S 345

S 347

F1

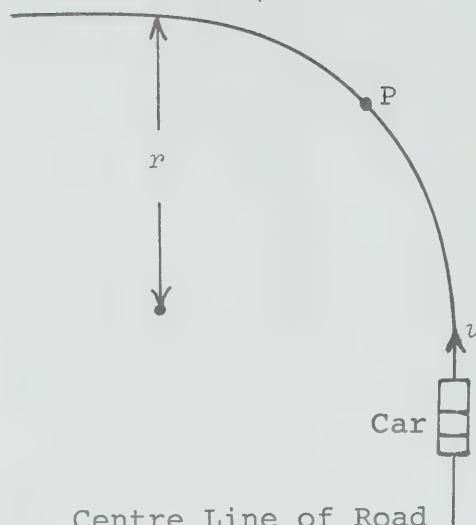
A8

A11

(D)

-

A car is about to turn an unbanked corner of radius r , as shown, at constant speed v . Inside the car are two balloons. The lighter balloon is filled with a gas less dense than air and fastened by a string to the floor. The heavier balloon is filled with a gas more dense than air and hung by a string from the ceiling. Both balloons are located in the middle of the car when the car travels in a straight line. The balloons are free to swing right or left within the car.



When the car is at point P on the curve,

- (A) both balloons are in the middle of the car.
- (B) both balloons lean toward the inside of the curve.
- (C) both balloons lean toward the outside of the curve.
- (D) the lighter balloon leans toward the inside of the curve while the heavier balloon leans toward the outside.
- (E) the heavier balloon leans toward the inside of the curve while the lighter balloon leans toward the outside.

8

S17C
III.2.c

S 33

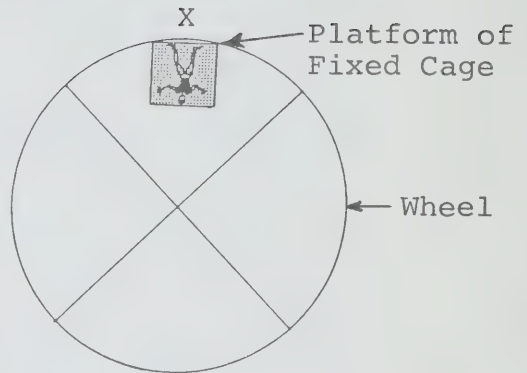
F1

A3

(D)

-

A giant wheel has a diameter of 40 m. The wheel is fitted with a fixed cage and platform on which a man of mass m can stand. The wheel is rotated vertically at such a speed that the force exerted by the man on the platform when the cage and platform are at position X is equal in magnitude to the force of gravity on the man. ($g = 10 \text{ m/s}^2$)



What is the net force on the man as the platform passes point X?

- (A) zero
- (B) mg down
- (C) mg up
- (D) $2 mg$ down
- (E) $2 mg$ up

9

S17C
III.1.d

35

F1

(B)

-

A 100 kg wagon rests on a frictionless surface. A man pushes the wagon from rest with a force of 1.0 kN over a distance of 2.0 m.

What maximum speed does it reach?

- (A) $\sqrt{10} \text{ m/s}$
- (B) $2\sqrt{10} \text{ m/s}$
- (C) 10 m/s
- (D) 40 m/s
- (E) $2.0 \times 10^3 \text{ m/s}$

10 A locomotive has a mass of 1.0×10^5 kg. The engineer operates it, when no cars are being pulled, in such a way that the engine exerts the maximum possible force at any speed. The force depends on the speed. The speed of the locomotive, as a function of time under these conditions, is shown in the graph below.

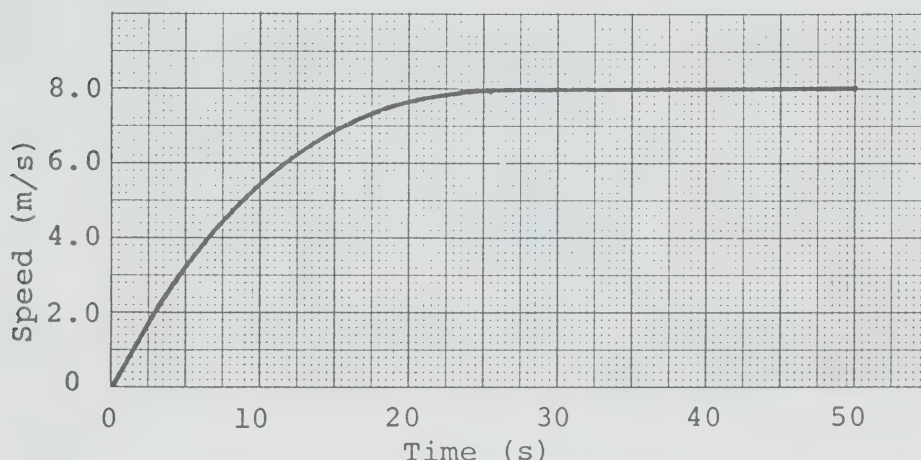
S17C
III.1.d

35
17

A7
F1
A8

(C)

-



Six cars, each having a mass of 5×10^4 kg, are attached to the locomotive, which exerts the same force as before. Frictional forces are negligible at speeds up to 10 m/s.

The acceleration of the train as it starts from rest will be given most closely as

- (A) 0.0 m/s^2
- (B) 0.1 m/s^2
- (C) 0.2 m/s^2
- (D) 0.3 m/s^2
- (E) 0.4 m/s^2

11

S17C
III.1.d

35

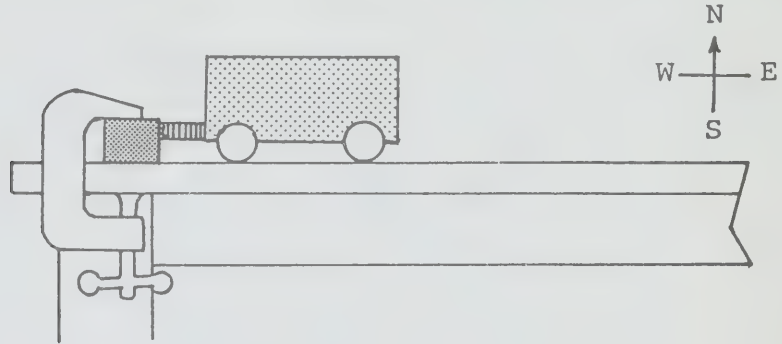
F1

A8

(B)

-
*

A cart, placed on a smooth, level table, has a spring attached to one end. The mass of the cart is 1.0 kg. The spring is compressed and placed in contact with a rigidly clamped block to the west of the cart as shown. The spring exerts a force of 20 N on the cart.



What is the acceleration of the cart when released?

- (A) zero
- (B) 20 m/s^2 [E]
- (C) 20 m/s^2 [W]
- (D) $1/20 \text{ m/s}^2$ [E]
- (E) $1/20 \text{ m/s}^2$ [W]

12

S17C
III.1.d

35

F1

A8

(B)

-

A certain force gives mass m_1 an acceleration of 12 m/s^2 . The same force gives mass m_2 an acceleration of 3.0 m/s^2 .

What acceleration would the force give to an object whose mass is the difference between m_1 and m_2 ?

- (A) 2.4 m/s^2
- (B) 4.0 m/s^2
- (C) 6.0 m/s^2
- (D) 9.0 m/s^2
- (E) The acceleration cannot be determined from the information given.

13

A 2.0 kg object was accelerated from 8.0 m/s to 14 m/s by a net force of 4.0 N.

S17C

III.1.d

How long did the net force act?

35

(A) 0.75 s

19

(B) 3.0 s

F1

(C) 4.0 s

(B)

(D) 7.0 s

-

(E) 12 s

14

Which graph best represents the gravitational force $\vec{F}$ near the surface of the earth as a function of mass m ?

S17C

III.2.a

S 35

A11

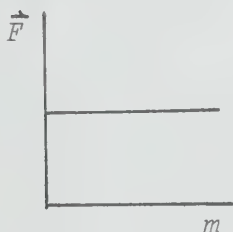
A3

(B)

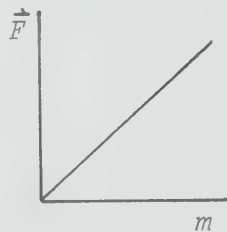
-

**

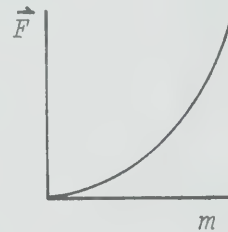
(A)



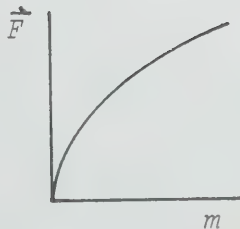
(B)



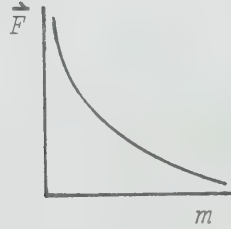
(C)



(D)



(E)



15

S17C

III.2.a

A jet vehicle on a smooth, level roadway on Earth can accelerate from rest to 1000 km/h in 36.0 s. The gravitational field strength on the planet Hexon is six times that on Earth.

35

F1

How long does it take the same jet vehicle on an identical roadway on Hexon to accelerate to 1000 km/h?

(C)

(A) 1.00 s

-

(B) 6.00 s

(C) 36.0 s

(D) $36.0\sqrt{6}$ s

(E) 216 s

16

S17C

III.2.a

Near the surface of the earth, which graph best represents acceleration due to gravity $\vec{g}$ as a function of mass m ?

S 35

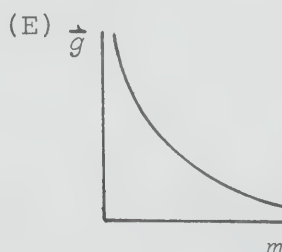
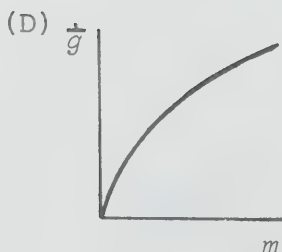
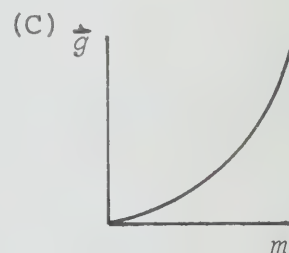
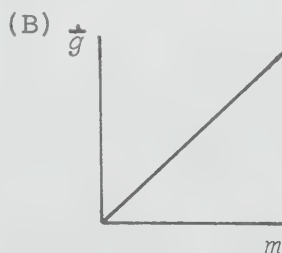
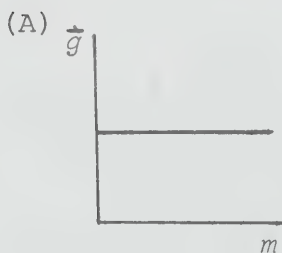
A11

A3

(A)

-

**



17

S17C
III.2.a

S 35

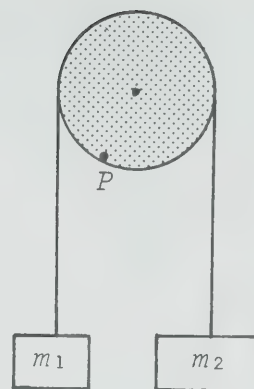
F1

A8

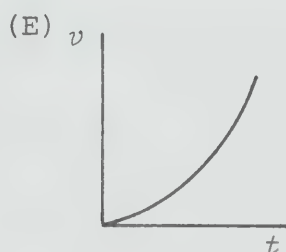
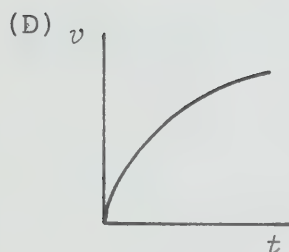
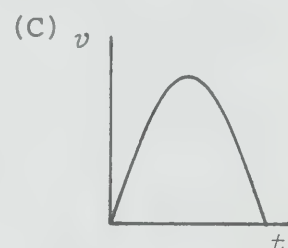
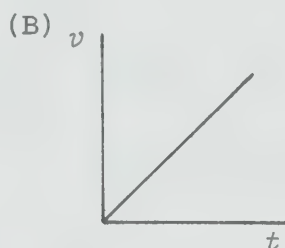
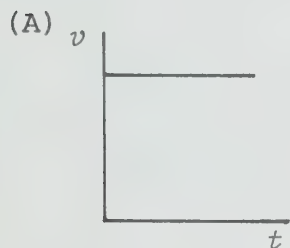
(B)

-

Two masses m_1 and m_2 are attached to opposite ends of a cord placed around a pulley as shown. There is no friction between the pulley and its axle, but there is friction between the string and the pulley. m_2 has a greater mass than m_1 . Both masses are held stationary at the same horizontal level as shown and then released.



Which of the following graphs best describes the speed v of the fixed point P on the pulley as a function of time t ?



18

A person holding a 10 kg mass enters an elevator at the top of a building. The motion of the elevator as it descends is shown by the velocity-time graph below.

S17C

III.2.a

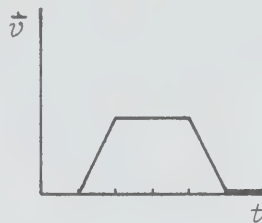
S 35

S 33

F1

A11

A3

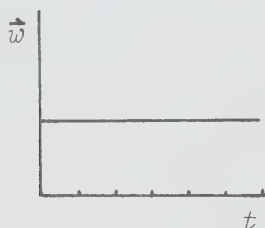


(C)

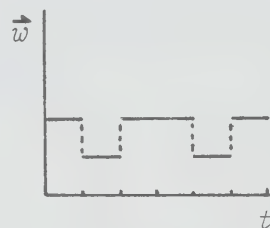
Which of the following graphs best describes the apparent weight $\vec{w}$ of the object to the person holding it as a function of time t .

-

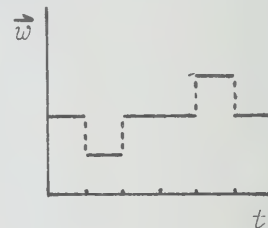
(A)



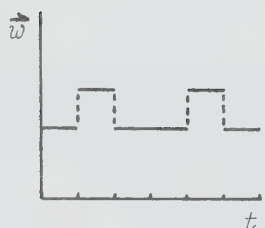
(B)



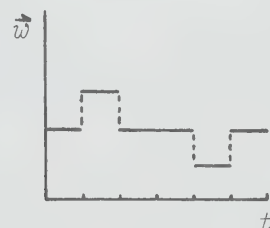
(C)



(D)



(E)

**19**

Inertial mass differs from gravitational mass in that the total inertial mass

S17C

III.1.c

36

A2

(D)

(A) is directly proportional to the volume of a pure substance

(B) is not additive for a number of different pure substances

(C) is not conserved in chemical reactions

(D) can be measured only when there is a change of motion

(E) can be measured only when there is uniform motion

-
**

20

S17C

III.1.d

S 35

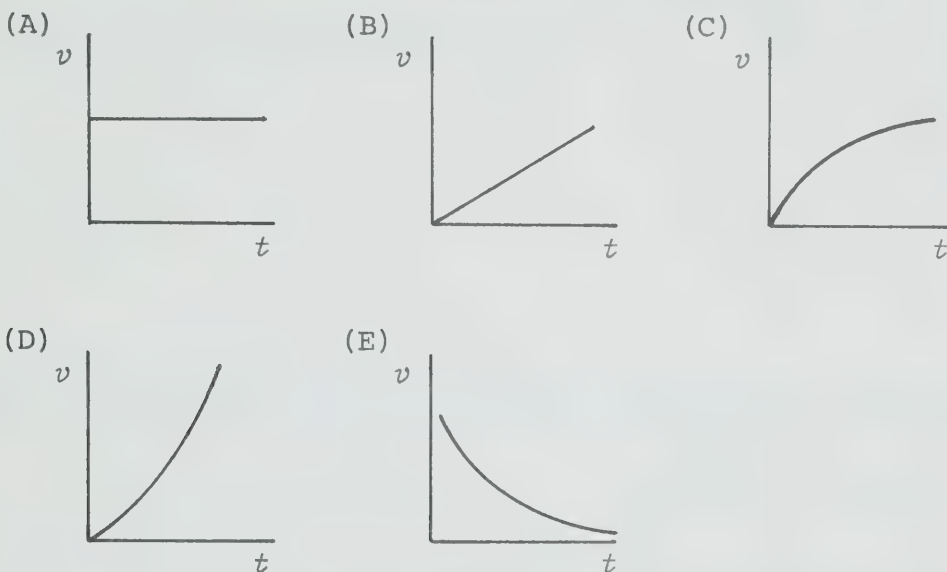
F1

A11

(D)

-

Half of the mass of a motorized toy car is fuel. If the fuel is consumed in such a way that the wheels exert a constant horizontal force on the roadway, which graph best represents the motion of the car?



21

S17C

III.1.c

36

A11

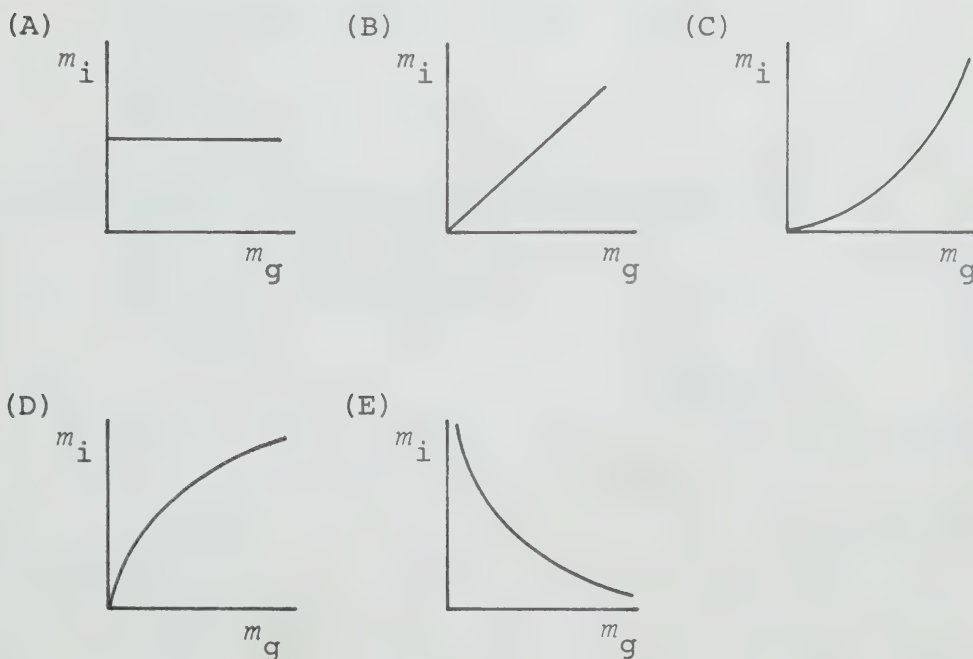
A3

(B)

-

**

Which graph best represents inertial mass m_i as a function of gravitational mass m_g ?



1 If a body is accelerating, it must be changing speed.

S17C

I.4.f

(A) True

32

(B) False

A8

(B)

-

2 An unbalanced force always changes the speed of an object.

S17C

III.1.d

(A) True

33

(B) False

A8

(B)

-

3 The acceleration of the moon as it orbits the earth is the same as that which a falling apple would have if it were at the same distance from the earth.

S17C

III.3.b

(A) True

35

40

(B) False

F1

A10

(A)

-

CENTRIPETAL FORCE AND GRAVITATION

1 This item involves two statements:

S17A I. Electrons orbit the nucleus of an atom.

IV.2.e

S17C II. The nucleus exerts a centripetal force on
IV.5.c the electron.

38 Which of the following responses correctly describes
126 the two statements according to the Bohr model of
the atom?

A8

E2 (A) Both statements are true and one statement can
be used to explain the other.

(A) (B) Both statements are true, but neither statement
can be used to explain the other.

-

**

(C) Statement I is true.
Statement II is false.

(D) Statement I is false.
Statement II is true.

(E) Statement I is false.
Statement II is false.

2

Which graph best represents the magnitude of the centripetal acceleration $\vec{a}$ as a function of radius of orbit r when speed is kept constant?

S17C

III.2.c

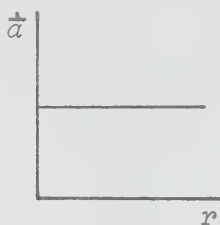
38

A11

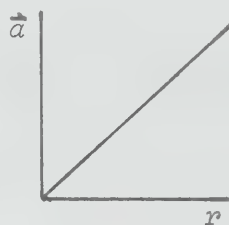
A3

(E)

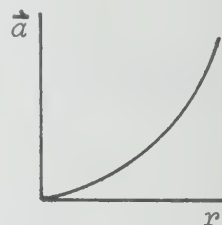
(A)



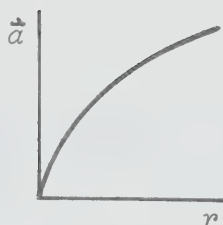
(B)



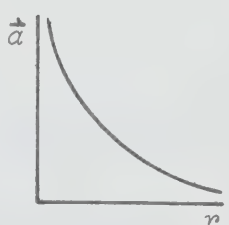
(C)



(D)



(E)



3

Which graph best represents the magnitude of the centripetal force F as a function of the speed v for an object moving in a fixed circular path?

S17C

III.2.c

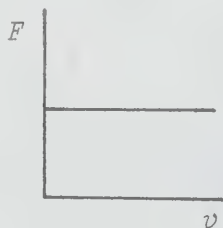
38

A11

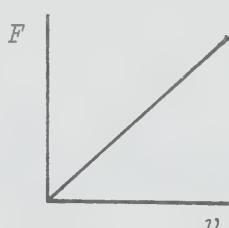
A3

(C)

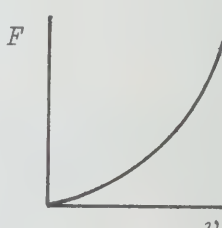
(A)



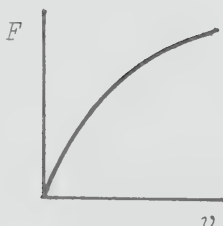
(B)



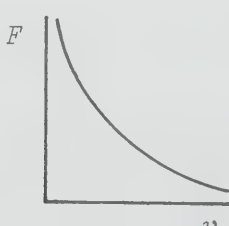
(C)



(D)



(E)



4 An object of mass 2.0 kg is moving in a circle of radius 3.0 m, at a speed of 2.0 m/s.

S17C
III.2.c What is the magnitude of the centripetal force on the particle?

38

(A) 0.38 N

F1

(B) 8.0 N

(C)

(C) 2.7 N

-

**

(D) 1.5 N

(E) 0.67 N

5 A passenger standing on a moving bus is carrying a heavy briefcase. The passenger exerts a force F to support the briefcase when the bus is moving along a straight level road at constant speed.

S17C
III.2.d

38 If the bus turns a sharp corner without changing speed, which one of the following statements is correct?

F1

(E) The force exerted by the man on the briefcase

-

(A) remains constant because the force of gravity and the centripetal force are at 90° to one another.

(B) remains constant because the gravitational force and the speed of the bus do not change.

(C) decreases because a component of the centripetal force acts upward balancing part of the force of gravity.

(D) increases because the passenger must provide the force to balance the force of gravity and the centrifugal force on the briefcase.

(E) increases because the passenger must provide a centripetal force in addition to a force to balance the force of gravity.

6

S17C

III.6.f

A ball of mass m , released from point X, travels around the frictionless loop-the-loop track of radius R . Assume the size of the ball is negligible.

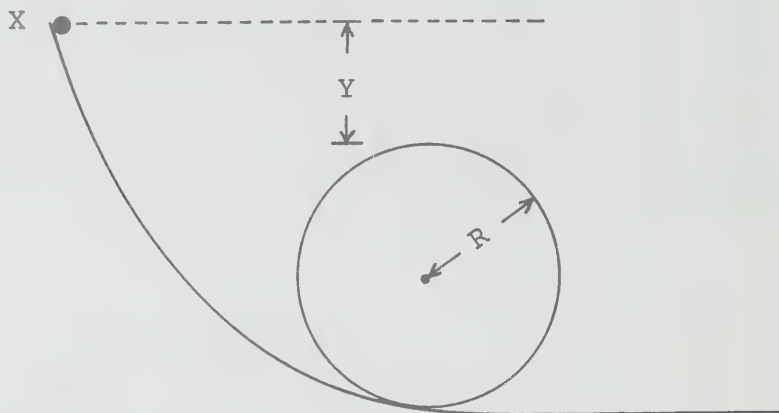
38

35

F1

(B)

-



What is the smallest value Y can have if the ball loops-the-loop without losing contact with the track?

(A) $\frac{R}{4}$

(B) $\frac{R}{2}$

(C) zero

(D) R

(E) $2 R$

7

An object of mass 2.0 kg is moving in a circle of radius 3.0 m, at a speed of 2.0 m/s.

S17C

III.2.c

What is the magnitude of the centripetal force on the particle?

38

(A) $0.38 \text{ s}^2/(\text{m}\cdot\text{kg})$

F1

(B) $8.0 \text{ kg}\cdot\text{m}/\text{s}^2$

(C)

(C) $2.7 \text{ kg}\cdot\text{m}/\text{s}^2$

-

**

(D) $1.5 \text{ kg}\cdot\text{s}^2/\text{m}$ (E) $0.67 \text{ kg}\cdot\text{m}/\text{s}^2$

8

The diagram shows an object tied to the end of a string moving counterclockwise in a circle at constant speed on a frictionless level surface. The distance travelled by the object in moving from W to X is 25 m. It takes the object 20 s to complete one revolution.

S17C

III.2.c

38

F1

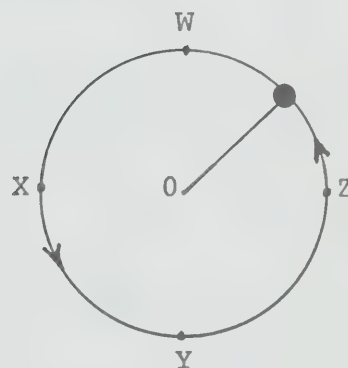
A3

A8

(C)

-

What is the magnitude of the centripetal acceleration of the object when it is at X?

(A) $0.31 \text{ m}/\text{s}^2$ (B) $1.3 \text{ m}/\text{s}^2$ (C) $1.6 \text{ m}/\text{s}^2$ (D) $3.9 \text{ m}/\text{s}^2$ (E) $6.3 \text{ m}/\text{s}^2$ 

9

S17C
III.2.d

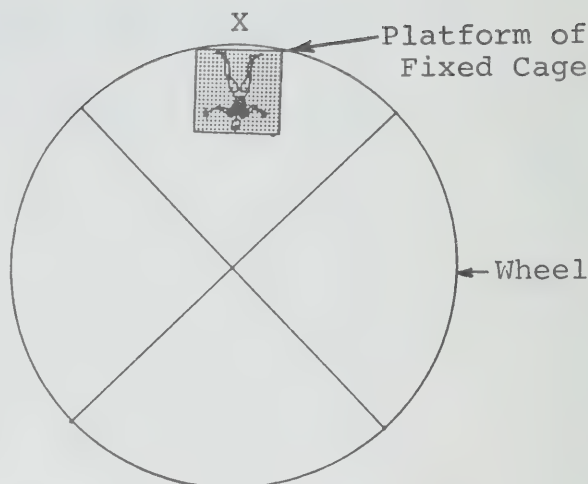
38

F1
A8

(B)

-

A giant wheel has a diameter of 40 m. The wheel is fitted with a fixed cage and platform on which a man of mass m can stand. The wheel is rotated vertically at such a speed that the force exerted by the man on the platform when the cage and platform are at position X is equal in magnitude to the force of gravity on the man. ($g = 10 \text{ m/s}^2$)



What is the speed of the platform as it passes point X? (Assume that the man's centre of mass is at the surface of the platform.)

- (A) 10 m/s
- (B) 20 m/s
- (C) 28 m/s
- (D) 80 m/s
- (E) $1.2 \times 10^2 \text{ m/s}$

10

S17C
III.2.c

38

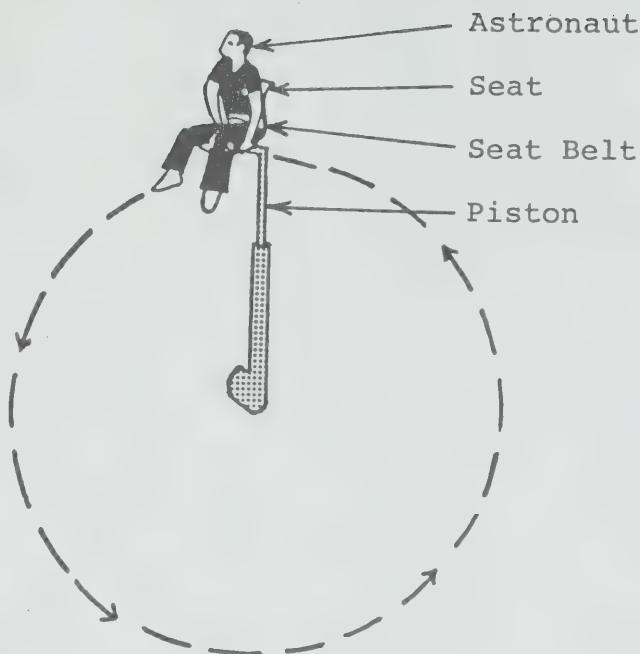
F1
A8
A5

(A)

-

A seat attached to the end of a long piston can be rotated in a vertical circle at varying speeds. The piston can also be shortened or lengthened to vary the radius.

An astronaut, of mass m , is secured in the seat with a seat belt as shown in the diagram. The astronaut is rotated in a vertical circle of radius r with a constant speed v .



If the length of the piston is increased to $2r$ and the speed is changed to $0.5v$, by what factor will the centripetal acceleration change?

(A) $\frac{1}{8}$

(B) $\frac{1}{4}$

(C) 1

(D) 2

(E) 4

11

S17C
III.2.c

38

F1

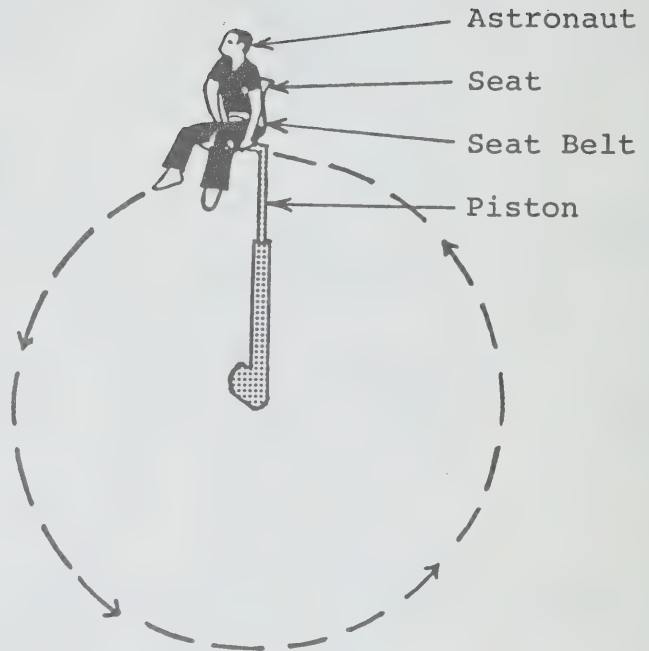
A8

A5

(D)

-

A seat attached to the end of a long piston can be rotated in a vertical circle at varying speeds. The piston can also be shortened or lengthened to vary the radius. An astronaut, of mass m , is secured in the seat with a seat belt as shown in the diagram. The astronaut is rotated in a vertical circle of radius r with a constant speed v .



If the speed of rotation stays constant, but the piston is shortened to produce a circle of radius $0.5 r$, the centripetal acceleration will

- (A) be quartered.
- (B) be halved.
- (C) remain the same.
- (D) be doubled.
- (E) be quadrupled

12

S17C
III.2.c

38

F1

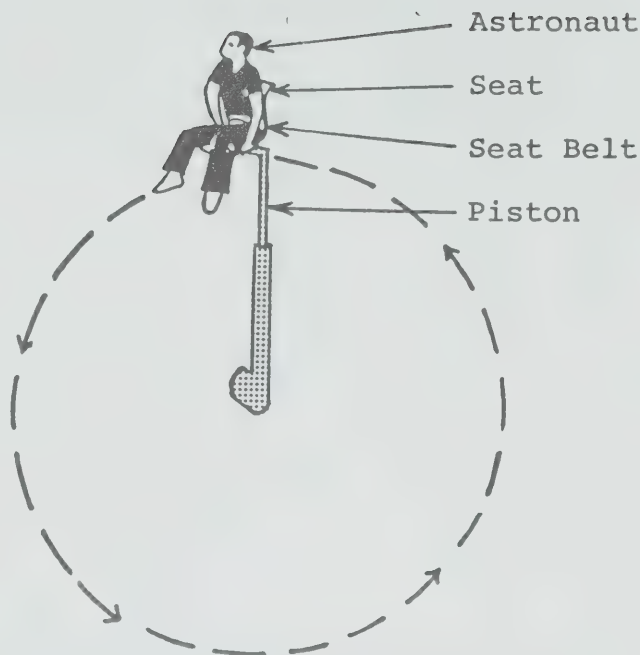
A8

A5

(E)

-
**

A seat attached to the end of a long piston can be rotated in a vertical circle at varying speeds. The piston can also be shortened or lengthened to vary the radius. An astronaut, of mass m , is secured in the seat with a seat belt as shown in the diagram. The astronaut is rotated in a vertical circle of radius r with a constant speed v .



If the length of the piston is maintained at r , but the speed of rotation is doubled, the centripetal acceleration will

- (A) be quartered.
- (B) be halved.
- (C) remain the same.
- (D) be doubled.
- (E) be quadrupled.

13

S17C
III.2.c

S 38

F1

(E)

-

A satellite 'weighs' 540 N at the earth's surface.

When the satellite is in orbit two earth-radii above the earth's surface, its 'weight' is

- (A) 270 N
- (B) 180 N
- (C) 135 N
- (D) 60 N
- (E) zero

14

The force of gravity on a satellite is 540 N at the earth's surface.

S17C

III.2.c

When the satellite is in orbit two earth-radii above the earth's surface, the force of gravity on the satellite is

S 38

F1

(A) 270 N

(D)

(B) 180 N

-

(C) 135 N

(D) 60 N

(E) zero

15

A small object of mass m on the end of a light cord is held horizontally at a distance r from a fixed support. The mass is released from this position.

S17C

III.6.f

S 38

F1

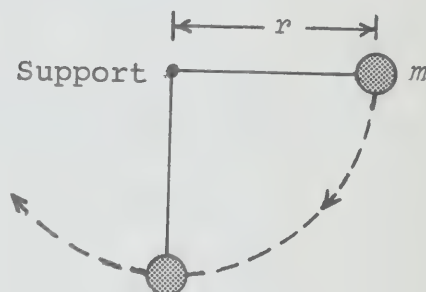
A8

A3

(D)

What is the magnitude of the force the cord exerts on the mass at the lowest point of its swing?

-

(A) $\frac{mg}{2}$ (B) mg (C) $2 mg$ (D) $3 mg$ (E) mgr 

16

S17C
 III.2.c

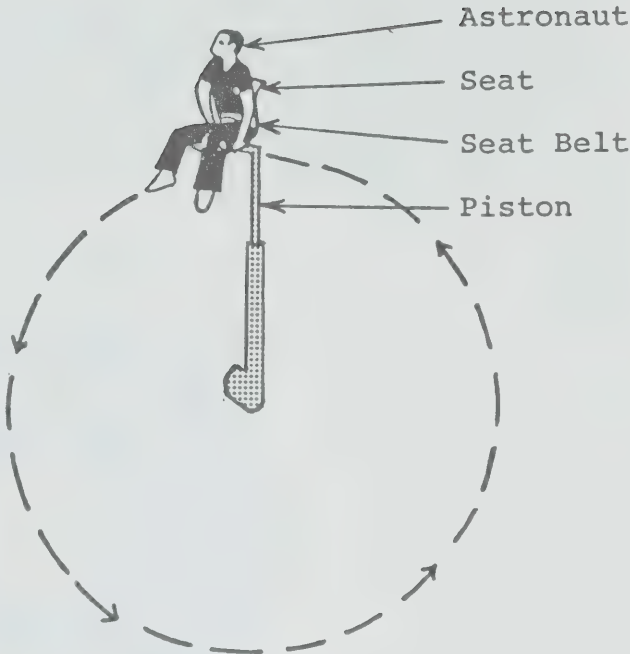
S 38

F1
 A8
 A5

(B)

-

A seat attached to the end of a long piston can be rotated in a vertical circle at varying speeds. The piston can also be shortened or lengthened to vary the radius. An astronaut, of mass m , is secured in the seat with a seat belt as shown in the diagram. The astronaut is rotated in a vertical circle of radius r with a constant speed v .



The astronaut is rotated on earth with a centripetal acceleration of g . Select the correct combination of forces that act on the astronaut at the top of the circle.

	Force of Gravity Downward	Force of Seat Belt Downward	Force of Seat Upward
(A)	0	mg	0
(B)	mg	0	0
(C)	0	mg	mg
(D)	mg	mg	0
(E)	mg	0	mg

17

S17C

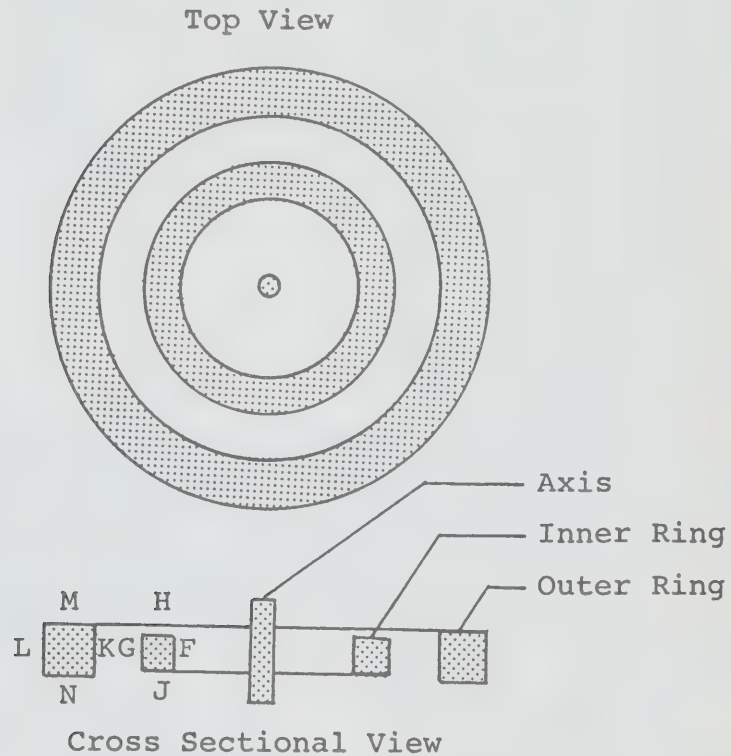
III.2.c

S 38

F1

(D)

The diagrams show a top view and a cross sectional view of a space wheel consisting of two rings. The wheel is placed in an orbit about the earth. An artificial force of gravity is created for astronauts by spinning the wheel. The inner ring spins one way and the outer ring spins the other way.



If an astronaut moves from the outer ring to the inner ring, the artificial force of gravity will

- (A) increase.
- (B) decrease.
- (C) stay the same.
- (D) depend on the speed with which each ring turns.
- (E) increase according to the inverse of the distance travelled inward.

18

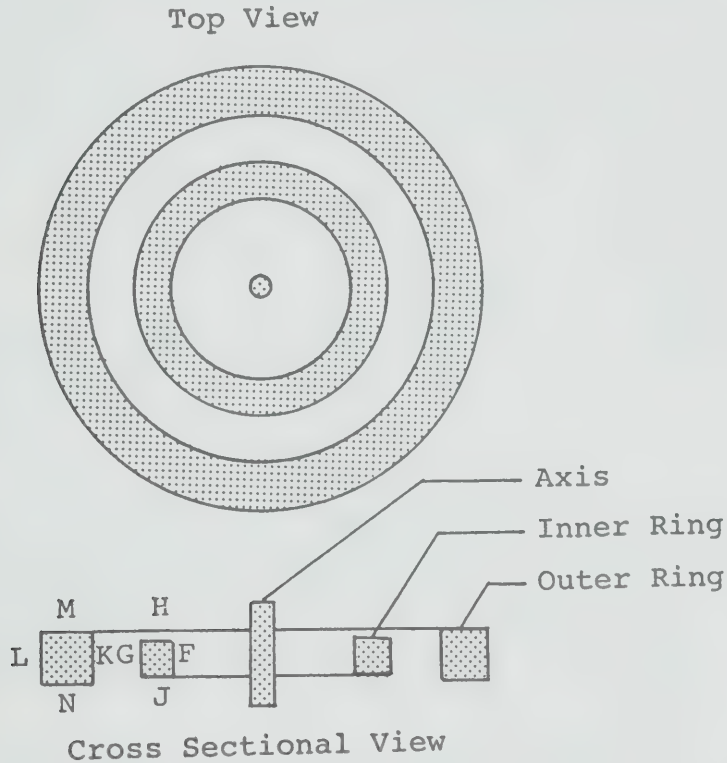
S17C
III.2.c

S 38

F1

(B)

The diagrams show a top view and a cross sectional view of a space wheel consisting of two rings. The wheel is placed in an orbit about the earth. An artificial force of gravity is created for astronauts by spinning the wheel. The inner ring spins one way and the outer ring spins the other way.



Consider the cross sectional view. If the astronauts stand on the 'left' side on both inner and outer rings, on which surfaces should their feet be planted?

- (A) on surfaces N and J
- (B) on surfaces L and G
- (C) on surfaces K and G
- (D) on surfaces K and F
- (E) on surfaces L and F

19S17C
III.2.c

Suppose that you have a pendulum clock which keeps correct time on earth. Without changing the clock in any way, you take it to the surface of the moon. ($g_e = 10 \text{ m/s}^2$; $g_m = 1.6 \text{ m/s}^2$)

SS 38

F1

For every elapsed time of 1.0 h as measured on the earth, the clock on the moon will read

(E)

(A) 10/1.6 h

-

(B) $\sqrt{10/1.6}$ h

(C) 1.0 h

(D) 1.6/10 h

(E) $\sqrt{1.6/10}$ h**20**S17C
III.3.a

Kepler's Third Law states that the cube of the radius of a planet's orbit R is directly proportional to the square of its period of revolution about the sun T . This law can be written as $R^3 = kT^2$, where k is the same for all planets orbiting the sun.

S 39

F1

(D)

If planet I has twice the orbital radius of planet II, what is the ratio of the period of planet I to the period of planet II?

-

(A) 2:1

(B) 4:1

(C) 8:1

(D) $\sqrt{8}$:1

(E) none of these

21 The derived unit for G , the universal gravitational constant, is the

- S17C
III.3.b (A) $\text{N}\cdot\text{m}$
- 40 (B) $\text{N}\cdot\text{m}/\text{kg}$
- A2 (C) $\text{N}\cdot\text{kg}/\text{m}$
- (D) (D) $\text{N}\cdot\text{m}^2/\text{kg}^2$
- (E) $\text{N}\cdot\text{kg}^2/\text{m}^2$
- ***

22 The derived unit for G , the universal gravitational constant, is the

- S17C
III.3.b (A) $\text{N}\cdot\text{m}$
- 40 (B) $\text{N}\cdot\text{m}\cdot\text{kg}^{-1}$
- A2 (C) $\text{N}\cdot\text{kg}\cdot\text{m}^{-1}$
- (D) (D) $\text{N}\cdot\text{m}^2\cdot\text{kg}^{-2}$
- (E) $\text{N}\cdot\text{kg}^2\cdot\text{m}^{-2}$
- ***

23 The universal gravitational constant is

$$G = 6.7 \times 10^{-11} \text{ m}^3/(\text{kg}\cdot\text{s}^2)$$

The gravitational force of attraction which exists between two spheres of mass 2.0 kg each, separated by 2.0 m from centre to centre, is

- 40 (A) 4.0 N
- A8 (B) 20 N
- (C) (C) $6.7 \times 10^{-11} \text{ N}$
- (D) $6.7 \times 10^{-11} \text{ kg}$
- * (E) $6.7 \times 10^{-11} \text{ kg}^2/\text{m}^2$

24S17C
III.3.b

A spring scale, calibrated in newtons, is used to weigh sugar at various locations. If it were possible to weigh sugar at the following locations, where will the buyer get the most sugar to a newton?

- 40 (A) on earth at the poles
A10 (B) on earth at the equator
(C) (C) at the centre of the earth
- (D) on the surface of the moon
*** (E) on the surface of the sun

25S17C
III.3.b

Mars has approximately one-ninth the mass of Earth, but the gravitational force at its surface is about one-third that of Earth. This indicates that

- 40 (A) Mars has a larger volume than Earth
F1 (B) Mars has a larger density than Earth
(C) (C) Mars has a smaller diameter than Earth
- (D) Mars is farther from the Sun than Earth
**** (E) Mars has one-ninth the acceleration due to gravity of Earth

26S17C
III.3.b

An astronaut on earth has a mass of 80 kg.
What is the force of gravity on the astronaut at a distance of one earth radius above the surface of the earth? ($g = 10 \text{ m/s}^2$)

- 40 (A) 800 N
F1 (B) 400 N
(C) (C) 200 N
- (D) 40 N
*** (E) 20 N

27

Planet X, with the same mass as Earth, has twice the diameter.

S17C

III.3.b

The ratio of the force of gravity on Planet X to the force of gravity on Earth is

40

(A) 4:1

F1

(B) 2:1

(E)

(C) 1:1

-

(D) 1:2

(E) 1:4

28

The diagram below illustrates the path of an imaginary planet travelling in an elliptical orbit about a star X. The letters P to W represent positions of the planet in its orbit.

S17C

III.3.b

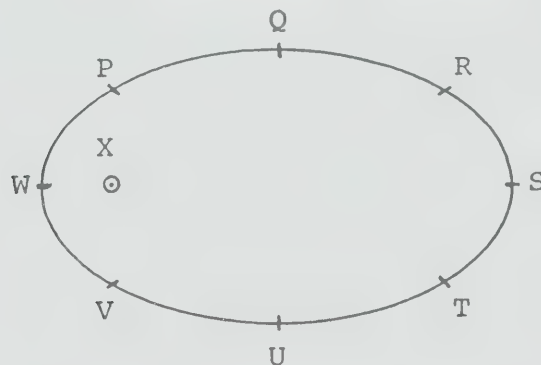
40

35

F1

(D)

-



The magnitude of the acceleration of the planet is

(A) the greatest at Q.

(B) the greatest at S.

(C) the greatest at U.

(D) the greatest at W.

(E) the same at all points.

29

S17C
III.3.b

The force of gravity on an object is 100 N at the earth's surface. The radius of the earth is 2 500 km.

40

F1

(E)

-

When the object is moved to a distance of 5 000 km from the surface of the earth, the force of gravity on it will be approximately

(A) 100 N

(B) 50 N

(C) 33 N

(D) 25 N

(E) 11 N

30

S17C
III.3.b

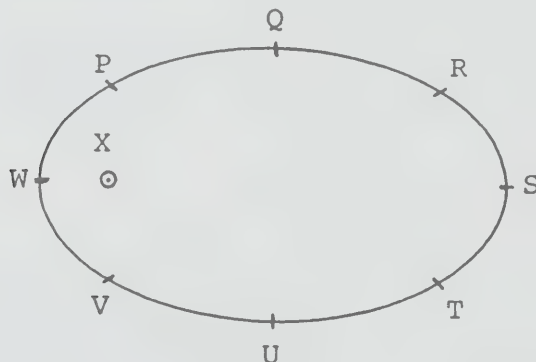
The diagram below illustrates the path of an imaginary planet travelling in an elliptical orbit about a star X. The letters P to W represent positions of the planet in its orbit.

40

F1

A8

(C)

-
**

At which point does the gravitational force of the star on the planet have the smallest magnitude?

(A) Q

(B) V

(C) S

(D) W

(E) The gravitational force has the same magnitude at all points.

31

S17C

III.3.b

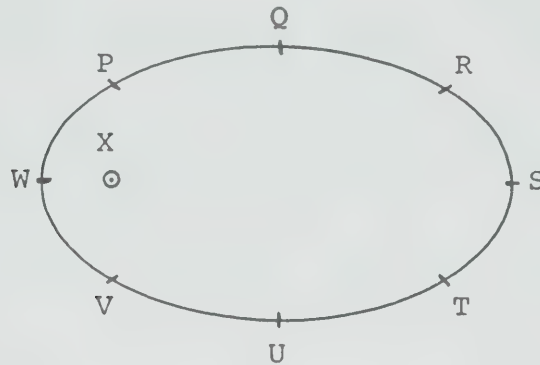
The diagram below illustrates the path of an imaginary planet travelling in an elliptical orbit about a star X. The letters P to W represent positions of the planet in its orbit.

40

35

F1

(B)

-
**

The magnitude of the acceleration of the planet is

- (A) the least at Q.
- (B) the least at S.
- (C) the least at U.
- (D) the least at W.
- (E) the same at all points.

32

Three statements describing motion are given below.

S17C

III.3.b

- I. Starting from rest, a body on earth falls 10 m in the first second.

S 40

A1

- II. In a vacuum, at a given location on earth, all objects fall with the same acceleration.

(A)

- III. An object, travelling with constant acceleration, covers equal distance in equal intervals of time.

-

Which of these statements is/are correct?

- (A) II only
- (B) I and II only
- (C) I and III only
- (D) II and III only
- (E) I, II and III

1 Kepler derived his three laws of planetary motion from principles of dynamics.

S17C

III.3.a (A) True

39 (B) False

I2

(B)

-

2 Newton showed that Kepler's three laws of planetary motion could be derived from his (Newton's) principles of dynamics.

S17C

III.3.b (A) True

39 (B) False

A1

(A)

-

**

IMPULSE AND CONSERVATION OF MOMENTUM

1 Which one of the following units cannot be used as a unit of momentum?

S17C

III.4.a

(A) $\text{kg}\cdot\text{m/s}$

41

(B) $\text{J}\cdot\text{s/m}$

A2

(C) $\text{J}/(\text{m/s})$

(D)

(D) $\text{J}\cdot\text{m/s}$

-

(E) $\text{N}\cdot\text{s}$

2 Momentum is expressed in

S17C

III.4.a

(A) J/s

(B) $\text{J}\cdot\text{m}$

41

(C) $\text{J}\cdot\text{s}$

A2

(D) $\text{N}\cdot\text{s}$

A1

(D)

(E) $\text{N}\cdot\text{m}$

-

**

3 Change in momentum can be expressed in .

S17C (A) J/s

III.4.a

(B) J·m

41

(C) J·s

A2

A3 (D) N·s

(D) (E) N·m

-
**

4 The SI derived unit with a compound name for momentum is the

S17C

III.4.a

(A) kg·m/s

41 (B) kg·m²/s

A11 (C) kg·m/s²

(A) (D) kg·m²/s²

- (E) kg·m²/s³

*

5 Impulse can be expressed in

S17C (A) J/s

III.4.a

(B) J·m

S 41

(C) J·s

A1

A2 (D) N·s

(D) (E) N·m

-

6

From the following list, select the one scalar quantity.

S17C

III.4.a

(A) acceleration

S 41

(B) distance

S 35

(C) force

A6

(D) impulse

(B)

(E) momentum

-

**

7

An astronaut travelling in space observes an object which seems to be rising toward the ship with uniform acceleration.

S17C

III.3.b

Which one of the following postulates should be immediately ruled out in attempting to explain the observation on the basis of physical principles?

S 41

F1

(A)

(A) The object is being uniformly accelerated toward the ship because of gravitational attraction to it.

-

(B) The astronaut is moving in a non-inertial frame of reference.

(C) The object is at rest and the astronaut is accelerating uniformly down toward it.

(D) The ship and the object are both in motion and either one, or both of them, are accelerating uniformly. If only one is accelerating, then the other may have uniform velocity.

(E) The astronaut is accelerating uniformly toward a reflection of the ship caused by some unfamiliar reflecting surface.

8

A train travels along a level track. Consider the following descriptions of the train:

S17C

III.4.b

42

A10

(B)

-

I. The train travels at constant speed around a curve.

II. The train slows down to pick up passengers at a station.

III. One of the cars of the train is filled with coal by having the train move at constant speed beneath a stationary coal chute.

IV. The train moves at constant velocity along the track.

In which of these cases is the momentum of the train constant?

(A) I only

(B) IV only

(C) I and II only

(D) I and IV only

(E) I, III and IV only

9

Two astronauts, each of mass 100 kg, are orbiting in space 200 km above the surface of the earth. The astronauts are separated by a distance of 10 m. One astronaut throws a 5.0 kg wrench, with a speed of 2.0 m/s relative to himself, directly towards the other astronaut.

S17C

III.4.b

42

F1

How long does it take the wrench to travel from one astronaut to the other?

(E)

-

(A) 0.19 s

(B) 0.20 s

(C) 4.8 s

(D) 5.0 s

(E) 5.3 s

10

S17C
III.4.b

42

F1

(E)

-

A driver in car X, travelling east at 60 km/h, strikes a brick wall and comes to rest in 0.15 s. A driver in car Y, travelling east at 30 km/h, has a head on collision with an identical car travelling west at 30 km/h, and both come to rest in 0.30 s. Assume that all drivers and cars have the same mass.

What is the ratio of the force on the driver in car X to the force on the driver in car Y?

- (A) 1:4
- (B) 1:2
- (C) 1:1
- (D) 2:1
- (E) 4:1

11

S17C
III.4.a

42

F1

(B)

-

A 0.20 kg rubber ball, initially at rest, is dropped from the window of a building. It strikes the sidewalk below with a speed of 30 m/s and rebounds from the sidewalk with a speed of 20 m/s. (Ignore any effect due to air friction.)

The magnitude of the impulse caused by the gravitational force during the time the ball falls is

- (A) 10 N·s
- (B) 6.0 N·s
- (C) 2.0 N·s
- (D) 2.0 N
- (E) 0.60 N·s

12

S17C
III.4.b

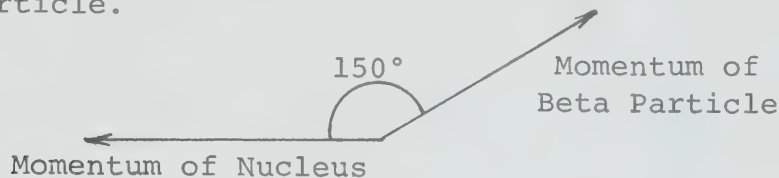
42

F1

(E)

-

A nucleus undergoing a radioactive disintegration is observed in a cloud chamber. A beta particle (electron) is emitted and the residual nucleus recoils at an angle of 150° to the direction of the beta particle. The accompanying vector diagram represents the momenta of the nucleus and the beta particle.



It is also known that a neutrino is emitted which leaves no visible track in the cloud chamber.

Which of the vectors below best represents the momentum of the neutrino?

(A)



(B)



(C)



(D)



(E)



13

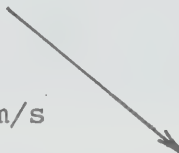
A soccer ball is approaching a player with a momentum of $30 \text{ kg}\cdot\text{m/s}$ in the direction shown.

S17C

III.4.b

42

25

 $30 \text{ kg}\cdot\text{m/s}$ 

F1

(E)

A goal will be scored only if the ball travels due north with a momentum of $50 \text{ kg}\cdot\text{m/s}$ after leaving the player's foot.

-

Which of the following impulses applied to the ball will produce a goal?

(A)



(B)



(C)



(D)



(E)



14

S17C
III.4.a

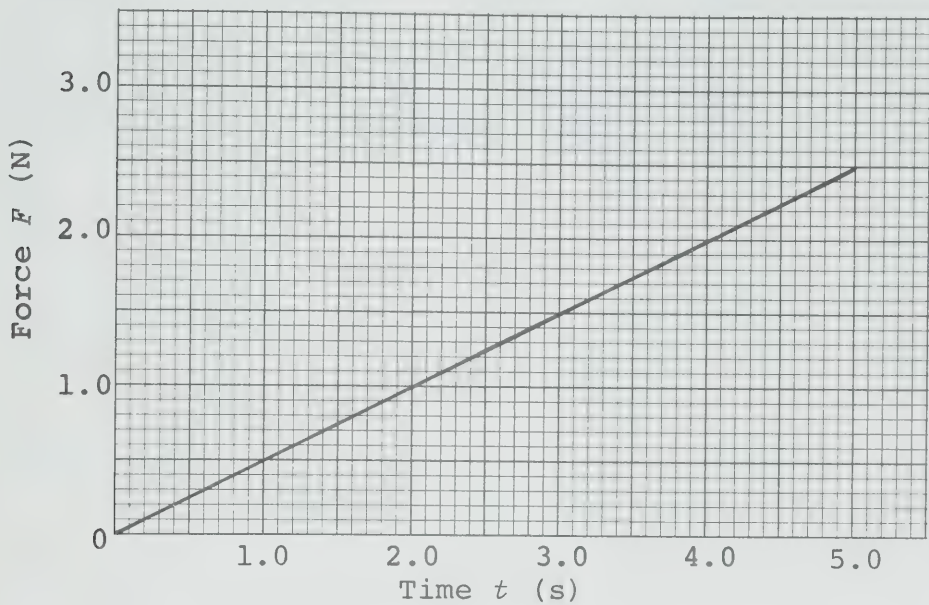
42

F1
A11

(B)

-

The graph below shows the net force as a function of time on a particle of mass 3 kg.



What is the magnitude of the change in velocity of the particle between $t = 2.0$ s and $t = 4.0$ s?

- (A) 0.67 m/s
- (B) 1.0 m/s
- (C) 2.0 m/s
- (D) 2.7 m/s
- (E) 3.3 m/s

15

The application of a horizontal impulse I to an object at rest on a level, frictionless surface gives it a speed v .

S17C

III.4.b

42

The application of another impulse of the same magnitude, but at 90° to the first, gives the object a final speed of

F1

A3

(A) zero

(C)

(B) v

-

**

(C) $\sqrt{2} v$ (D) $\sqrt{2} v$ (E) $2 v$

16

A stream of gas is composed of n molecules. Each molecule has a mass m and is travelling at a speed of v . The beam is reflected elastically from a rigid surface as shown in the diagram. The relative lengths of the sides of a common triangle are also shown.

S17C

III.4.b

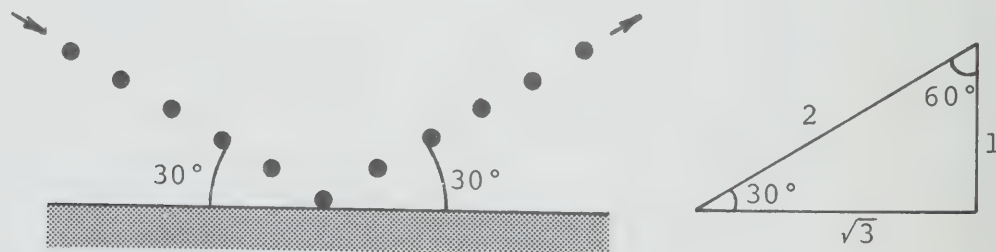
42

F1

D3

(E)

-



What is the magnitude of the total change in momentum of the stream?

(A) $2 mnv$ (B) $2 mnv \sin 60^\circ$ (C) $mnv \sin 60^\circ$ (D) $mnv \cos 60^\circ$ (E) mnv

17

S17C
III.5.b
III.4.a

A given mass, initially at rest, is subjected to consecutive impulses I_1 and I_2 . I_1 causes the mass to acquire a kinetic energy E_k . I_2 causes it to further increase its kinetic energy to $4 E_k$.

Which of the following equations best describes the relationship between the two impulses?

42
53

F1

(B)

-

(A) $I_2 = 0.5 I_1$

(B) $I_2 = I_1$

(C) $I_2 = 2 I_1$

(D) $I_2 = 3 I_1$

(E) $I_2 = 4 I_1$

18

S17C
III.4.b

Sphere X of mass 2 kg, moving with a speed of 10 m/s, collides head on with sphere Y of mass 4 kg, moving in the opposite direction with a speed of 10 m/s.

Which statement best describes the magnitude of the impulse exerted by each sphere during the collision?

S 42

A8

(D)

-

(A) The impulse exerted by X on Y is 4 times the impulse exerted by Y on X.

(B) The impulse exerted by X on Y is 2 times the impulse exerted by Y on X.

(C) The impulse exerted by X on Y is $\sqrt{2}$ times the impulse exerted by Y on X.

(D) The impulse exerted by X on Y is equal to the impulse exerted by Y on X.

(E) It is not possible to compare impulses without knowing whether or not the collision is elastic.

19

The SI derived unit with a compound name for impulse is the

S17C

III.4.a

(A) $\text{kg}\cdot\text{m}/\text{s}$

S 42

(B) $\text{kg}\cdot\text{m}^2/\text{s}$

A2

(C) $\text{kg}\cdot\text{m}/\text{s}^2$

A1

(D) $\text{kg}\cdot\text{m}^2/\text{s}^2$

(A)

(E) $\text{kg}\cdot\text{m}^2/\text{s}^3$

-

**

20

Two stationary objects R and S, resting on a smooth surface, are released at the same time and move toward each other under the influence of the force of gravitational attraction between them. At any instant during the motion, R has twice the speed of S.

S17C

III.4.b

S 42

A3

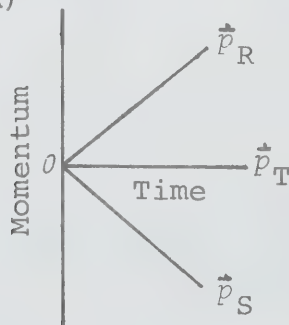
A5

A11

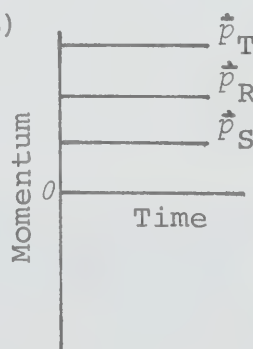
Which one of the following graphs represents the individual momentum of R ($\vec{p}_R$) and S ($\vec{p}_S$) and the total momentum of the system ($\vec{p}_T$) as a function of time after release?

-

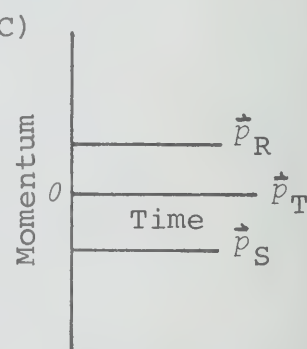
(A)



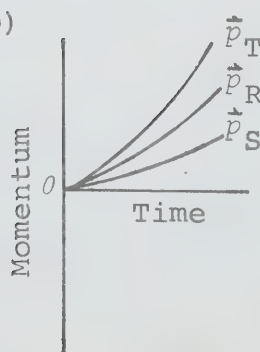
(B)



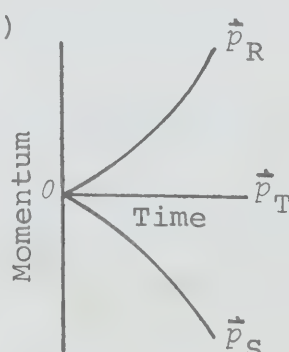
(C)



(D)



(E)



21

S17C
III.4.b

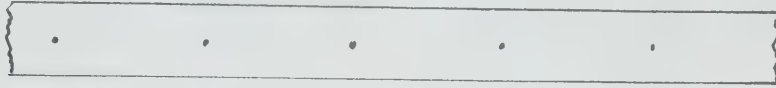
43

A8
A11

(C)

-

Cart X of mass 2 bricks is attached to a ticker tape which passes through a recording timer. Cart X is given a uniform velocity on a frictionless surface. The diagram below shows the ticker tape record of the motion of cart X.

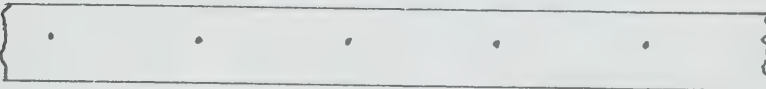


Cart X collides with an identical cart Y at rest and they become coupled together. Which of the diagrams shows the ticker tape record of the motion after the collision?

(A)



(B)



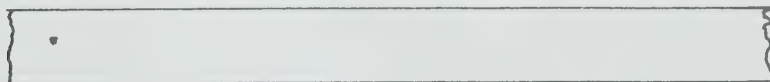
(C)



(D)



(E)



22

S17C
III.4.b

A cart loaded with sand rolls along a frictionless horizontal track. As the cart moves, the sand trickles out through a hole in the floor at the back of the cart.

43
32

The speed of the cart will

A8
A10

(A) decrease at a constant rate

(B) increase at a constant rate

(C)

(C) remain the same

-

(D) increase, but not at a constant rate

(E) decrease, but not at a constant rate

23

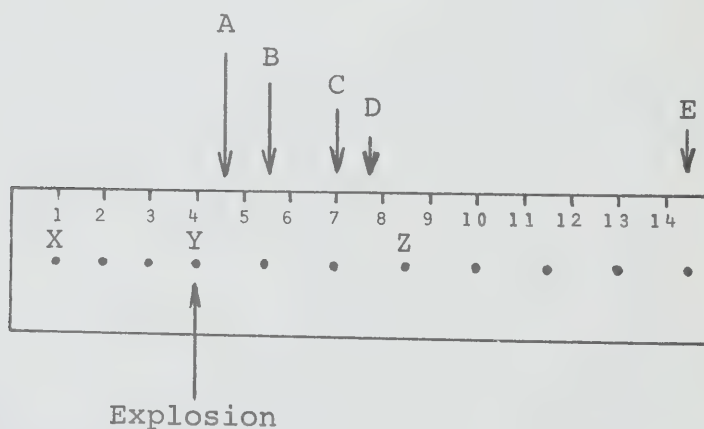
S17C
III.4.b

A multiframe, operating at a flash rate of 1 Hz, was used to take the picture shown superimposed on the ruler.

43

F1

(B)

-
***

Two carts of equal mass and attached together travelled between X and Y. At Y an explosion separated the carts and a record was made for only one cart. This cart reached point Z three seconds after the explosion.

Where is the other cart at this time?

(A) A

(B) B

(C) C

(D) D

(E) E

24

S17C

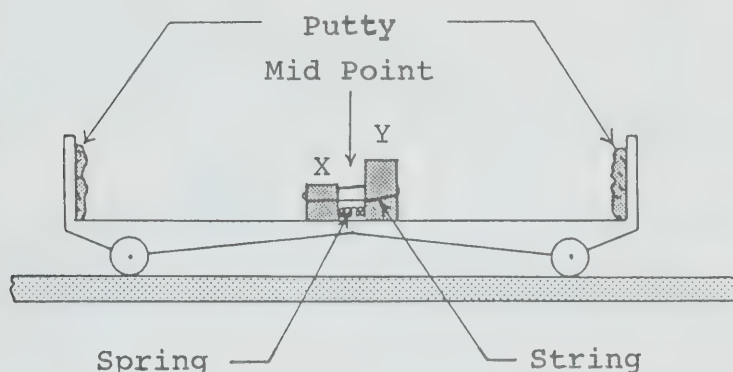
III.4.b

43

F1

(B)

A long, level car of mass 3.0 kg is free to move on a frictionless surface. An air puck X of mass 2.0 kg is tied with a string to an air puck Y of mass 4.0 kg with a compressed spring between them. The two pucks are placed on the frictionless surface of the car at its mid point as shown. When the string is burned, the spring between the pucks pushes the pucks apart. Pieces of putty at the ends of the car trap the air pucks.



What will be the motion of the pucks and the car as soon as the string is burned?

- (A) Puck X moves to the left at the same speed as puck Y moves to the right and the car remains at rest.
- (B) Puck X moves to the left faster than puck Y moves to the right and the car remains at rest.
- (C) Puck X moves to the left slower than puck Y moves to the right and the car remains at rest.
- (D) Puck X moves to the left faster than puck Y moves to the right and the car moves to the right.
- (E) Puck X moves to the left slower than puck Y moves to the right and the car moves to the left.

25

S17C

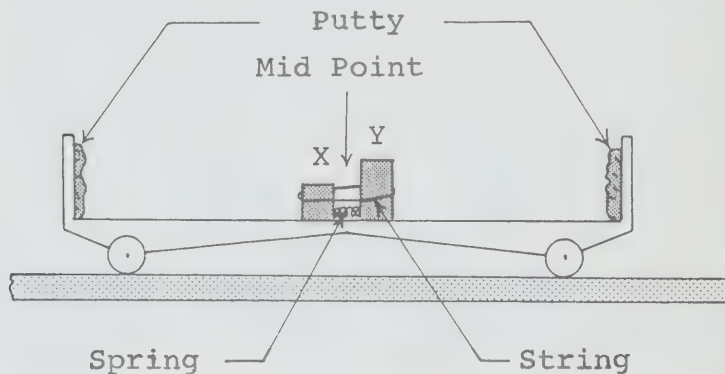
III.4.b

43

F1

(D)

A long, level car of mass 3.0 kg is free to move on a frictionless surface. An air puck X of mass 2.0 kg is tied with a string to an air puck Y of mass 4.0 kg with a compressed spring between them. The two pucks are placed on the frictionless surface of the car at its mid point as shown. When the string is burned, the spring between the pucks pushes the pucks apart. Pieces of putty at the ends of the car trap the air pucks.



What will be the motion of the car after the first puck hits the putty?

- (A) The car will remain stationary since both pucks hit the pieces of putty at the same time.
- (B) The car will move to the left and then to the right and stop at its original location.
- (C) The car will move to the right and then to the left and stop at its original location.
- (D) The car will move to the left and then to the right and stop to the left of its original location.
- (E) The car will move to the right and then to the left and stop to the right of its original location.

26

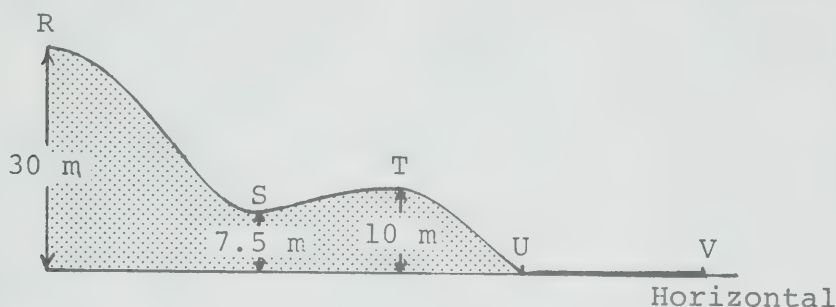
S17C
III.5.d

A cross section of a frictionless downhill ski run shows the vertical height, in metres, above the horizontal for various locations. A skier, whose mass is 75 kg, starts downhill at R. ($g = 10 \text{ m/s}^2$)

S 43

F1
A8

(D)

-
***

A stationary skier of mass 50 kg jumps into the moving skier's arms at point U.

Which one of the following statements about the collision is false?

- (A) The collision between the two skiers is inelastic since the two skiers stick together after the collision.
- (B) The momentum lost by the moving skier is equal to the momentum gained by the stationary skier.
- (C) The velocity of the two skiers after the collision is 0.6 times the velocity of the moving skier before the collision.
- (D) The velocity of the skiers after the collision can be calculated using the Law of Conservation of Energy.
- (E) The impulse the moving skier gives to the stationary skier is equal in magnitude to the impulse the stationary skier gives to the moving skier.

27

S17C

III.5.d

A steel block, moving in a frictionless groove, collides with a stationary block of putty. The two blocks stick together after the collision. Consider the following statements:

43

I. Kinetic energy is conserved.

F1

A8

II. Momentum is conserved.

(D)

III. The temperature of each block increases.

Which of the above statements is/are correct?

-

(A) I only

(B) II only

(C) I and II only

(D) II and III only

(E) I, II and III

28

S17C

III.5.d

44

F1

(D)

-

A moving sphere collides elastically with an identical stationary sphere. The final paths of the two spheres after collision are at an angle θ to each other. $\vec{p}_1$ is the momentum of the moving sphere prior to collision, and $\vec{p}_1'$ and $\vec{p}_2'$ are the momenta of the two spheres after the collision. Consider the following statements:

I. $\vec{p}_1 = \vec{p}_1' + \vec{p}_2'$ II. $p_1^2 = (p_1')^2 + (p_2')^2$ III. $\theta = 90^\circ$ IV. $\theta < 90^\circ$ V. $\theta > 90^\circ$

Which statement or combination of statements is true?

(A) I only

(B) I and III only

(C) I and IV only

(D) I, II and III only

(E) I and V only

29

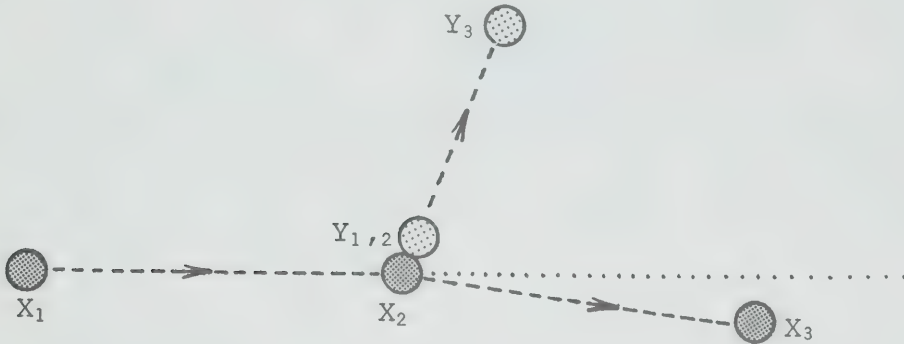
S17C
III.4.b

44

F1
A8

(A)

A time lapse photograph of a collision between two spheres X and Y is shown below. Sphere X, which has a mass of 4.0 kg, collides with sphere Y which is stationary. The subscripts show successive positions.



What is the mass of Y based on the positions of X and Y after impact?

- (A) 1.0 kg
- (B) 2.0 kg
- (C) 4.0 kg
- (D) 8.0 kg
- (E) 12 kg

30

S17C
III.5.d

S 44

F1

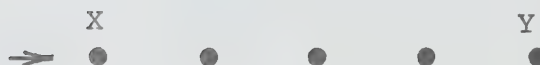
(E)

-

A stroboscopic photograph shows the motion of a steel ball as it travels along a smooth, level table from X to Y to Z. Between X and Y the ball has a speed of 20 m/s.

P
O

Z ●



Which one of the following statements correctly accounts for the change in motion of the steel ball at Y?

- (A) A magnet at Z is switched on when the ball reaches Y.
- (B) A magnet at P is switched on when the ball reaches Y.
- (C) A jet of air, fired from Z toward Y, hits the ball when it reaches Y.
- (D) The ball is refracted at Y as it starts to roll down an inclined plane.
- (E) None of the above statements accounts for the motion.

31

S17C
III.4.b

A mass m_1 , moving with a velocity v , collides with a stationary mass m_2 on a frictionless air table. m_2 has three times the mass of m_1 . The masses stick together after the collision.

S 44

F1

(B)



Which tape shows the correct speeds of m_1 before and after the collision?

- (A)
- (B)
- (C)
- (D)
- (E)

1

S17C

III.5.d

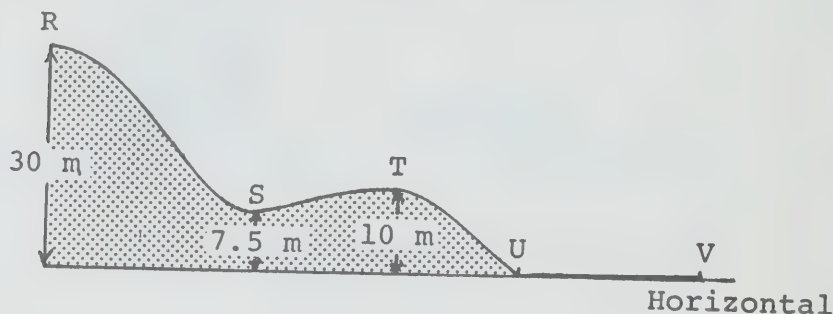
A cross section of a frictionless downhill ski run shows the vertical height, in metres, above the horizontal for various locations. A skier, whose mass is 75 kg, starts downhill at R. ($g = 10 \text{ m/s}^2$)

S 43

F1

A8

(A)



A stationary skier of mass 50 kg jumps into the moving skier's arms at point U.

The collision between the two skiers is inelastic since the two skiers stick together after the collision.

(A) True

(B) False

2

S17C

III.5.d

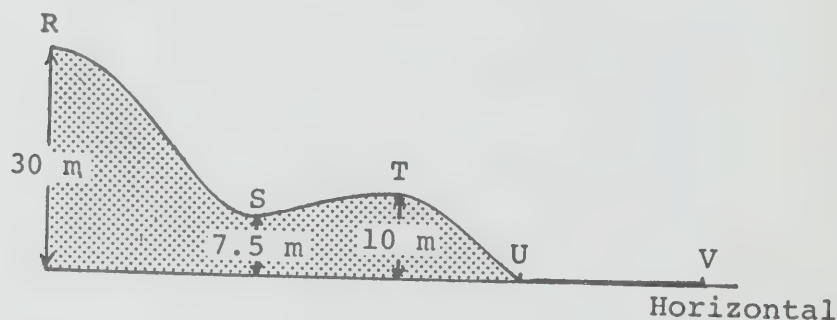
A cross section of a frictionless downhill ski run shows the vertical height, in metres, above the horizontal for various locations. A skier, whose mass is 75 kg, starts downhill at R. ($g = 10 \text{ m/s}^2$)

S 43

F1

A8

(A)



A stationary skier of mass 50 kg jumps into the moving skier's arms at point U.

The velocity of the two skiers after the collision is 0.6 times the velocity of the moving skier before the collision.

(A) True

(B) False

3

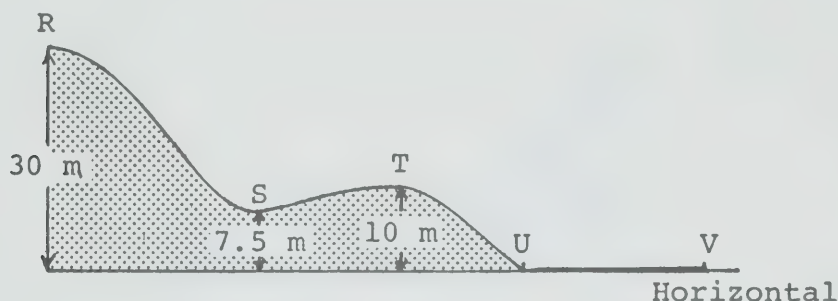
S17C
III.5.d

A cross section of a frictionless downhill ski run shows the vertical height, in metres, above the horizontal for various locations. A skier, whose mass is 75 kg, starts downhill at R. ($g = 10 \text{ m/s}^2$)

S 43

F1
A8

(A)

-
***

A stationary skier of mass 50 kg jumps into the moving skier's arms at point U.

The momentum lost by the moving skier is equal to the momentum gained by the stationary skier.

- (A) True
(B) False

4

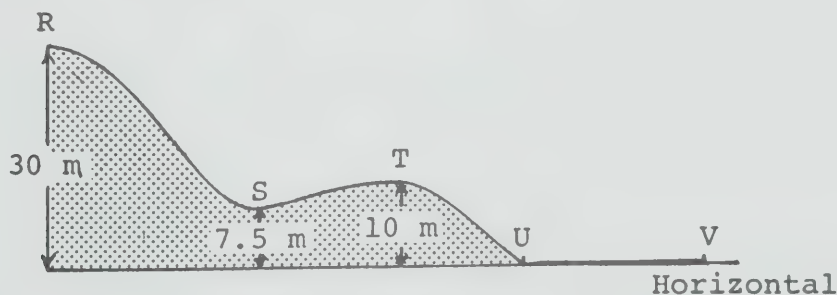
S17C
III.5.d

A cross section of a frictionless downhill ski run shows the vertical height, in metres, above the horizontal for various locations. A skier, whose mass is 75 kg, starts downhill at R. ($g = 10 \text{ m/s}^2$)

S 43

F1
A8

(B)

-
***

A stationary skier of mass 50 kg jumps into the moving skier's arms at point U.

The velocity of the skiers after the collision can be calculated using the Law of Conservation of Energy.

- (A) True
(B) False

5

S17C

III.5.d

A cross section of a frictionless downhill ski run shows the vertical height, in metres, above the horizontal for various locations. A skier, whose mass is 75 kg, starts downhill at R. ($g = 10 \text{ m/s}^2$)

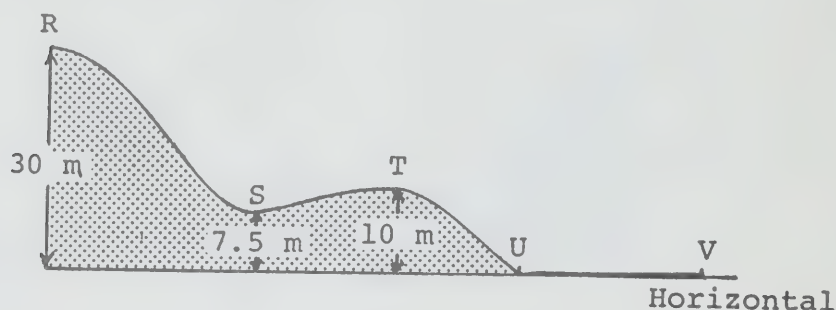
S 43

F1

A8

(A)

-



A stationary skier of mass 50 kg jumps into the moving skier's arms at point U.

The impulse the moving skier gives to the stationary skier is equal in magnitude to the impulse the stationary skier gives to the moving skier.

(A) True

(B) False

WORK AND

KINETIC ENERGY

1 Select the one vector quantity from the following list.

S17C
III.5.b

(A) energy

S 46
S 41

(B) impulse

A3
A6

(C) mass

(D) speed

(B)

(E) work

-
**

2 Select the one vector quantity from the following list:

S17C
III.5.b

(A) distance

S 46
S 41

(B) energy

(C) momentum

A6
A2

(D) speed

(C)

(E) work

-
**

3

S17C

III.5.b

47

35

F1

(E)

-

Two masses, m_1 and m_2 , have the same kinetic energy and are moving in the same direction. The same retarding force is applied to each mass.

If $m_1 = 4 m_2$, the ratio of the stopping distance of m_1 to the stopping distance of m_2 will be

(A) 1:4

(B) 4:1

(C) 1:2

(D) 2:1

(E) 1:1

4

S17C

III.6.c

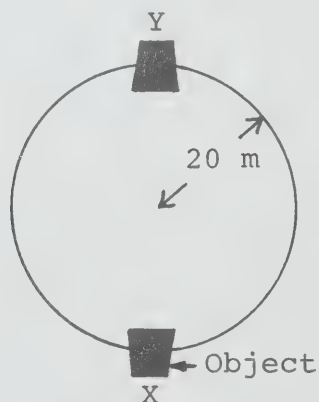
47

F1

(C)

-

An object of mass 10 g is moved in a vertical plane from position X to position Y in a time of 0.75 min on a circular track of radius 20 m. ($g = 10 \text{ m/s}^2$)



How much work is done?

(A) 1.0 J

(B) 2.0 J

(C) 4.0 J

(D) 6.0 J

(E) 12 J

- 5** The joule is a unit of
- S17C (A) energy
III.6
S 48 (B) force
S 46 (C) momentum
S 41 (D) power
S 35
A2 (E) None of the above is correct.
(A)

-
*

- 6** The N·s is a unit of
- S17C (A) acceleration
III.5.b
(B) energy
S 48
S 46 (C) force
S 41
S 35 (D) momentum
A2 (E) power
A3
(D)

-
**

- 7** The N·m is a unit of
- S17C (A) acceleration
III.5.b
(B) energy
S 48
S 46 (C) force
S 41
S 35 (D) momentum
A2 (E) power
A11
(B)

-

8 The J/s is a unit of

S17C (A) energy

III.6

(B) force

S 48

S 46

(C) momentum

S 41

S 35

(D) power

A2

(E) work

(D)

-

**

9

A machine can lift a 50 kg object at a constant speed a distance of 10 m in a time of 2.0 s.

S17C

III.6

The power of the machine is

49

(A) 2.5×10^3 W

A8

(B) 1.0×10^3 W

(A)

(C) 5.0×10^2 W

-

(D) 2.5×10^2 W

(E) 1.0×10^2 W

10

The instantaneous power developed by an object is defined as the rate of doing work or the rate at which energy is being transferred in a small interval of time. A 1 kg mass, initially at rest, is allowed to fall freely for several seconds.

S17A

I.3.d

S17C

III.6.b

The power developed at the end of the first second of fall is closest to

S 49

F1

(A) zero

(E)

(B) 1 J/s

-

(C) 1×10^1 J/s

(D) 5×10^1 J/s

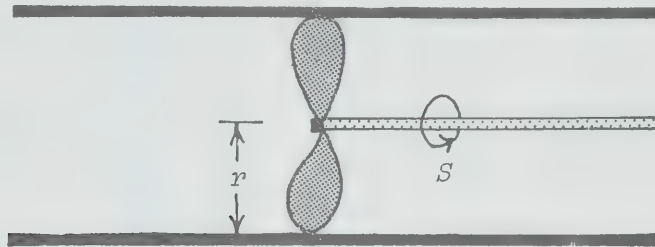
(E) 1×10^2 J/s

- 11 An ideal fluid flows through an impeller. The physical characteristics of the system are the radius of the impeller and pipe r , the speed of rotation of the impeller S , the density of the fluid D , the volume flow rate through the impeller V , and the power to turn the impeller P .

F1
A10

(A)

-



The power required to turn the impeller varies directly as the density of the fluid and directly as the cube of the speed of rotation of the impeller. The volume flow rate varies directly as the speed of rotation of the impeller and directly as the cube of the radius of the impeller.

What impeller and pipe radius is required to maintain a flow rate of V if the rotational speed is increased from S to $8 S$?

- (A) $\frac{r}{2}$
- (B) $\frac{r}{3}$
- (C) $\frac{r}{4}$
- (D) $\frac{r}{8}$
- (E) $\frac{r}{16}$

12

S17C
I.2.c

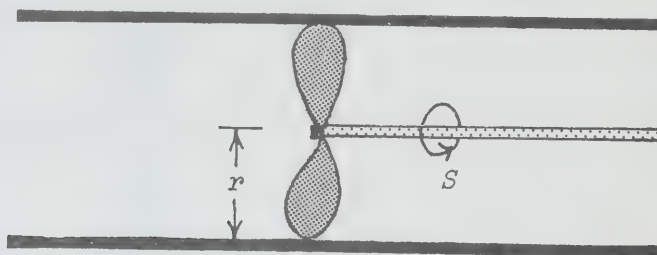
S 49

F1
A10

(E)

-
**

An ideal fluid flows through an impeller. The physical characteristics of the system are the radius of the impeller and pipe r , the speed of rotation of the impeller S , the density of the fluid D , the volume flow rate through the impeller V , and the power to turn the impeller P .



The power required to turn the impeller varies directly as the density of the fluid and directly as the cube of the speed of rotation of the impeller. The volume flow rate varies directly as the speed of rotation of the impeller and directly as the cube of the radius of the impeller.

What is the power required to operate the impeller if the speed is changed from S to $4 S$?

- (A) $4 P$
- (B) $4 SP$
- (C) $12 SP$
- (D) $16 SP$
- (E) $64 P$

13

S17C

I.2.c

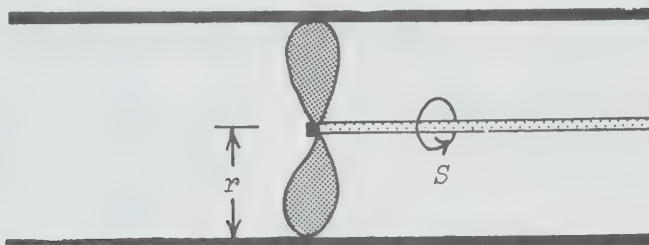
S 49

F1

A10

(A)

An ideal fluid flows through an impeller. The physical characteristics of the system are the radius of the impeller and pipe r , the speed of rotation of the impeller S , the density of the fluid D , the volume flow rate through the impeller V , and the power to turn the impeller P .



The power required to turn the impeller varies directly as the density of the fluid and directly as the cube of the speed of rotation of the impeller. The volume flow rate varies directly as the speed of rotation of the impeller and directly as the cube of the radius of the impeller.

What is the power required to operate the impeller if the density is decreased from D to D_f ?

(A) $\frac{PD_f}{D}$

(B) $\frac{PD}{D_f}$

(C) $\frac{D}{PD_f}$

(D) PD_f

(E) $P(D - D_f)$

14

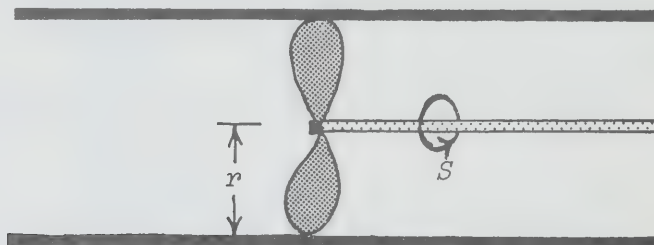
S17C
I.2.c

S 49

F1
A10

(D)

An ideal fluid flows through an impeller. The physical characteristics of the system are the radius of the impeller and pipe r , the speed of rotation of the impeller S , the density of the fluid D , the volume flow rate through the impeller V , and the power to turn the impeller P .



The power required to turn the impeller varies directly as the density of the fluid and directly as the cube of the speed of rotation of the impeller. The volume flow rate varies directly as the speed of rotation of the impeller and directly as the cube of the radius of the impeller.

What is the flow rate if the speed of rotation is changed from S to S_f and the radius is changed from r to r_f ?

(A) $V \left(\frac{r}{r_f} \right)^3 \frac{S}{S_f}$

(B) $V \left(\frac{r}{r_f} \right)^3 \frac{S_f}{S}$

(C) $V \left(\frac{r_f}{r} \right)^3 \frac{S}{S_f}$

(D) $V \left(\frac{r_f}{r} \right)^3 \frac{S_f}{S}$

(E) Cannot be determined from the information given.

15

A body moves in a circle at constant speed. The work done by the centripetal force on this body is zero, because

S17C

III.5.a

50

A3

(E)

-

- (A) the net displacement of the body after each revolution is zero.
- (B) the average force on the body over each revolution is zero.
- (C) there is no friction on a body moving in a circle at constant speed.
- (D) the magnitude of the acceleration of the body is zero.
- (E) the centripetal force on the body and the direction of its motion are perpendicular at every instant.

16

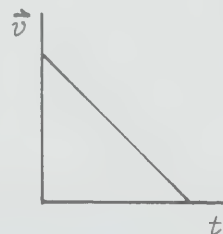
The straight line motion of an object is described by the velocity-time graph shown.

S17C

III.5.b

S 51

S 17



A11

D3

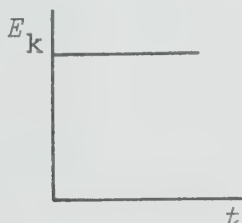
F1

Which one of the graphs shown below best describes the kinetic energy of the object as a function of time?

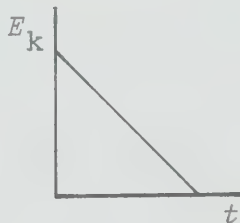
(C)

-

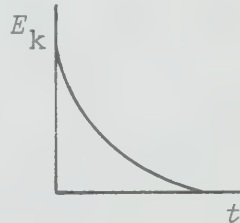
(A)



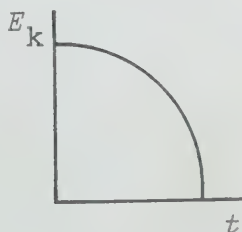
(B)



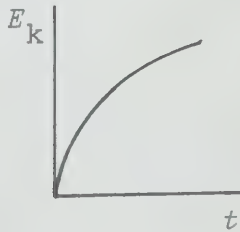
(C)



(D)



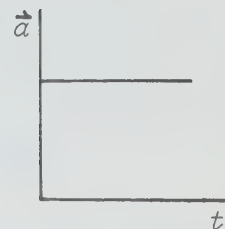
(E)



17

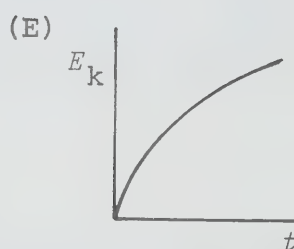
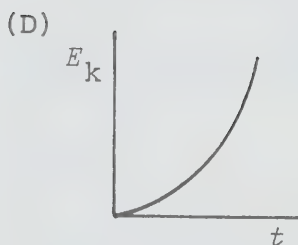
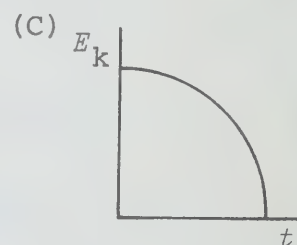
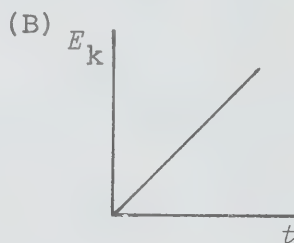
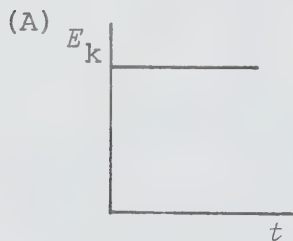
S17C
III.5.b

The straight line motion of an object is described by the acceleration-time graph shown.

S 51
S 19A11
D3
F1

Which one of the graphs shown below best describes the kinetic energy of the object as a function of time?

(D)

-
***

18

S17C
III.5.b

A Toronto Blue Jays baseball player catches a ball of mass m which is moving horizontally toward him with a speed v relative to the ground.

52
47

If his hand moves back a distance d while bringing the ball to rest, the magnitude of the average horizontal force exerted on the ball by his hand is

F1
A8

(A) $\frac{mv^2}{d}$

(E)

(B) $mv d$

-

(C) $\frac{mv}{d}$

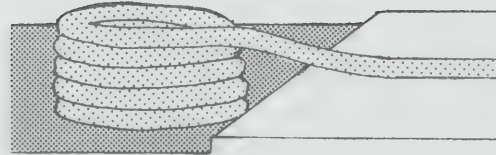
(D) $\frac{2}{d} mv$

(E) $\frac{mv^2}{2d}$

19

S17C
III.5.b

A flexible rope is uncoiled by pulling the end of the rope horizontally along a smooth surface at the steady speed of 2.0 m/s as shown.



52

F1
A8
A3

Assuming that the rope has a mass per unit length of 0.25 kg/m, the work required to uncoil 10 m of the rope is

(B)

(A) zero

-
**

(B) 5.0 J

(C) 10 J

(D) 15 J

(E) 20 J

20S17C
III.5.c

S 52

F1

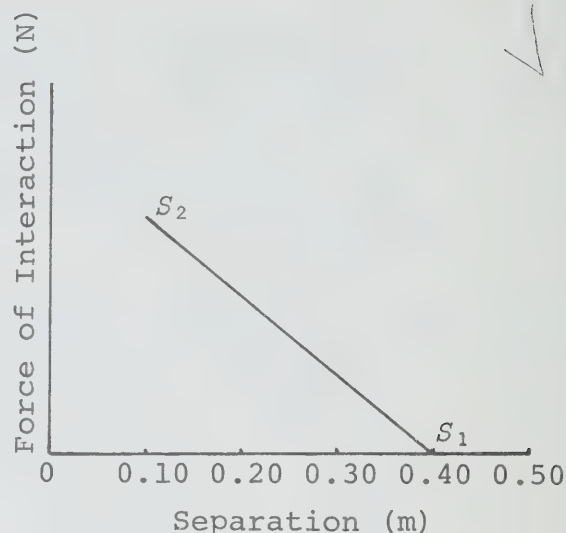
A8

A3

(E)

-

Object P has a kinetic energy of 36 J. It collides elastically with object Q which has a kinetic energy of 12 J. The force-separation graph shows that the collision begins when the separation S_1 is 0.40 m. Minimum separation S_2 is 0.10 m. The total kinetic energy of the system at minimum separation is 30 J.



What is the maximum repulsive force between objects P and Q?

- (A) $4.5 \times 10^1 \text{ N}$
- (B) $6.0 \times 10^1 \text{ N}$
- (C) $9.0 \times 10^1 \text{ N}$
- (D) $1.0 \times 10^2 \text{ N}$
- (E) $1.2 \times 10^2 \text{ N}$

21S17C
III.5.b

S 53

F1

(B)

-

Object R has twice the mass, but the same momentum, as object S.

If the kinetic energy of object R is E_k what is the kinetic energy of object S?

- (A) E_k
- (B) $2 E_k$
- (C) $4 E_k$
- (D) $\frac{1}{2} E_k$
- (E) $\frac{1}{4} E_k$

22S17C
III.6.b

A mass m , initially moving to the right with velocity $\vec{v}$ on a frictionless surface, compresses a linear spring having a force constant k .

S 52
S 56A8
F1

(A)

When the kinetic energy of the mass equals the potential energy of the spring, the expression for the amount of spring compression x is

(A) $x = \sqrt{\frac{1}{2} \frac{m}{k}} v$

(B) $x = \frac{1}{2} m v^2$

(C) $x = \frac{1}{4} m v^2$

(D) $x = \frac{1}{4} \frac{m v^2}{k}$

(E) $x = \sqrt{\frac{m v}{k}}$

23S17C
III.5.b

The application of a horizontal impulse to an object at rest on a level frictionless surface gives it a kinetic energy E_k .

S 53
42

The application of another impulse to the moving object of the same magnitude, but at 90° to the first, gives the object a final kinetic energy of

F1

(A) zero

(D)

(B) E_k -
***(C) $\sqrt{2} E_k$ (D) $2 E_k$ (E) $4 E_k$

24

The application of a horizontal impulse to an object at rest on a level frictionless surface gives it a kinetic energy E_k .

S17C

III.5.b

The application of another impulse to the moving object of the same magnitude and direction gives the object a final kinetic energy of

S 53

42

F1

(A) zero

(E)

(B) E_k -
***(C) $\sqrt{2} E_k$ (D) $2 E_k$ (E) $4 E_k$ **25**

If two different masses have the same kinetic energy, their momenta are

S17C

III.5.b

(A) proportional to their masses

S 53

42

(B) proportional to the squares of their masses

F1

(C) proportional to the square roots of their masses

(C)

(D) inversely proportional to the squares of their masses

-

(E) inversely proportional to the square roots of their masses

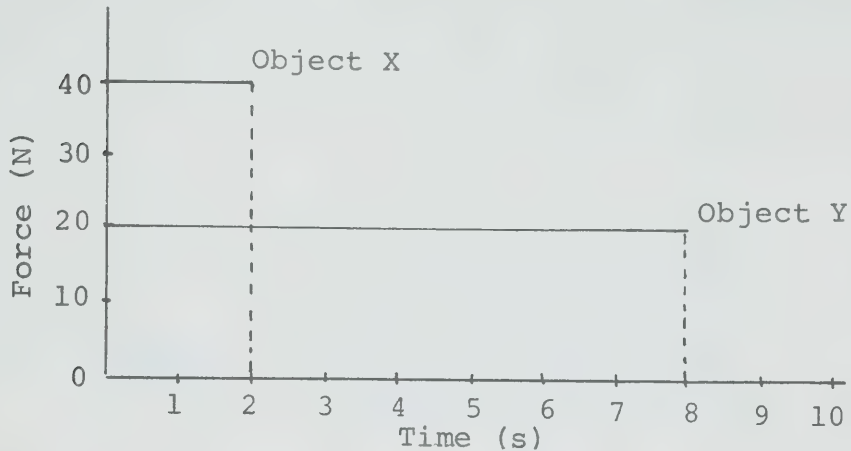
26

S17C
III.5.bS 53
S 42
33F1
A11
A3
A8

(B)

-

Two objects X and Y of equal mass are at rest on a smooth table. The graph below shows the forces applied to the objects as a function of time.



Which of the following statements is correct for the objects?

- (A) The impulse applied to Y is half the impulse applied to X.
- (B) The final momentum of Y is twice the final momentum of X.
- (C) The final kinetic energy of Y is twice the final kinetic energy of X.
- (D) The force required to stop Y is twice the force required to stop X.
- (E) The time to stop Y is twice the time to stop X.

27

S17C

III.4.b

54

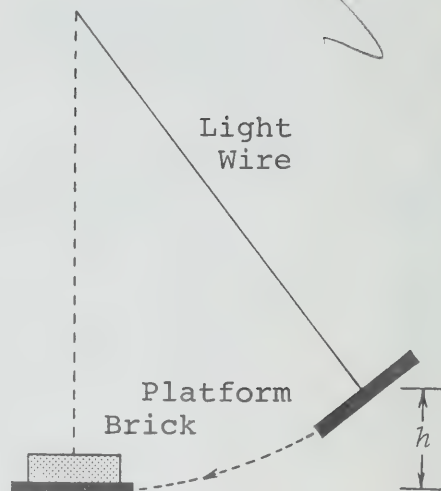
F1

(D)

-

A platform having a mass of 1.0 kg is suspended by a long light wire. With the wire drawn tight, the platform is swung in an arc until it is h metres above the lowest position. The platform is released from this position.

Just as the platform passes through its lowest position, a stationary brick of mass 2.0 kg is dropped onto the platform from a negligible height. The brick immediately sticks to the platform.



What is the relationship between the kinetic energy E_{k1} of the platform at the lowest position just before the brick is dropped, and the kinetic energy E_{k2} of the platform and the brick just after the brick strikes the platform?

(A) $E_{k2} = 3 E_{k1}$

(B) $E_{k2} = E_{k1}$

(C) $E_{k2} = \frac{1}{2} E_{k1}$

(D) $E_{k2} = \frac{1}{3} E_{k1}$

(E) $E_{k2} = \frac{1}{9} E_{k1}$

28

A hard sphere makes an elastic collision with a second identical sphere initially at rest.

S17C
III.5.c For all collisions, except head on, the angle between the velocity vectors after the collision is

54

- A1 (A) 30°
(D) (B) 45°
- (C) 60°
*** (D) 90°
(E) variable

29

Cart X makes a slow elastic collision with cart Y which is at rest. The masses of the two carts are equal.

S17C
III.5.d

S 54

A8

(E)

-
**

Which one of the following statements is not correct?

- (A) Some kinetic energy disappears temporarily during the collision.
(B) Cart X is at rest and cart Y is moving after the collision.
(C) Carts X and Y have the same velocity at minimum separation.
(D) The kinetic energy, which disappears during the collision, is stored as potential energy.
(E) The total momentum before the collision is greater than the momentum after the collision.

30

Consider the following statements about a collision between two bodies.

S17C

III.5.d

I. The total kinetic energy remains constant throughout the collision.

S 54

II. The total momentum remains constant throughout the collision.

A8

(D)

III. The total energy remains constant throughout the collision.

-

Which of these statements apply to an elastic collision?

- (A) III only
- (B) I and II only
- (C) I and III only
- (D) II and III only
- (E) I, II and III

31

A mass m_1 of 1.5 kg, moving at a velocity v_1 , collides head on with a stationary mass m_2 of 2.0 kg.

S17C

III.5.c

S 54

What is the motion of m_1 and m_2 after the collision if the collision is totally inelastic?

F1

(C)

-

- (A) m_1 is stationary and m_2 moves in the original direction of m_1 with a velocity of $3/7 v_1$.
- (B) m_1 rebounds with a velocity of $4/7 v_1$, and m_2 moves forward with a velocity of $3/7 v_1$.
- (C) m_1 and m_2 stick together and move forward with a velocity of $3/7 v_1$.
- (D) m_1 and m_2 stick together and move forward with a velocity of $7/3 v_1$.
- (E) m_1 moves forward with a velocity of $4/7 v_1$ and m_2 with a velocity of $3/7 v_1$.

32S17C
III.5.d

A perfectly elastic ball of mass m drops onto the surface of a perfectly elastic earth. The ball has a velocity v at the instant of contact.

Which one of the following statements is correct?

S 54

F1

(C)

-

(A) The ball bounces back to its original height because the law of conservation of momentum dictates that the ball must retain all its speed.

(B) The ball bounces back to its original height because the earth exerts a greater impulse on the ball than the ball does on the earth.

(C) The ball bounces back to its original height because all the kinetic energy it possesses at the ground level is transformed back into potential energy.

(D) The ball receives an impulse from the earth of magnitude mv .

(E) The earth gains momentum from the ball of magnitude mv .

33S17C
III.6.a

Two carts, X and Y, are at rest and have a spring bumper compressed between them. Cart X has a mass $\frac{2}{5}$ of the mass of cart Y.

Assuming no friction, what is the ratio of the kinetic energy of cart X to the kinetic energy of cart Y after the carts are released and separate?

S 54

S 43

F1

A8

(D)

-

(A) $\frac{2}{5}$

(B) $\frac{4}{25}$

(C) $\frac{25}{4}$

(D) $\frac{5}{2}$

(E) $\frac{1}{1}$

34

S17C

III.5.d

Two particles, X and Y, undergo a perfectly elastic collision. Just prior to the collision, Y is at rest and X has a speed of 10 m/s. The mass of Y is twice the mass of X, and there is no friction.

S 54

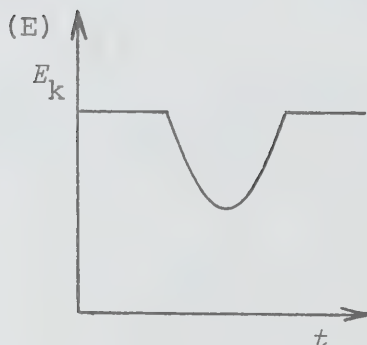
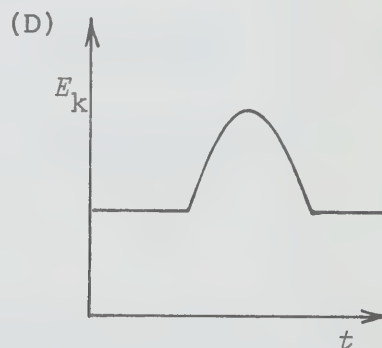
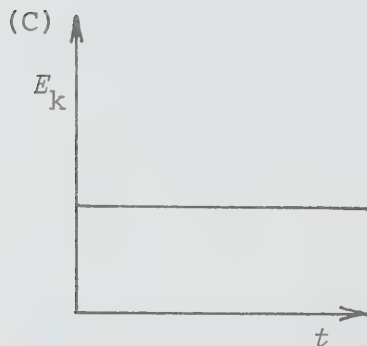
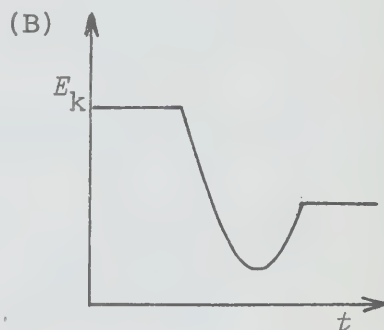
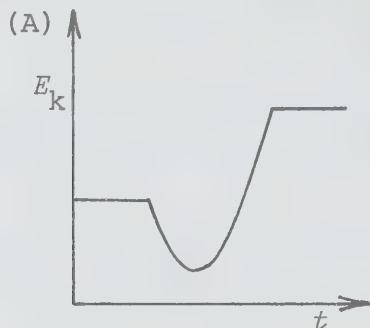
Which is the best graph of the total kinetic energy, E_k , against time, t ?

F1

All

(E)

-



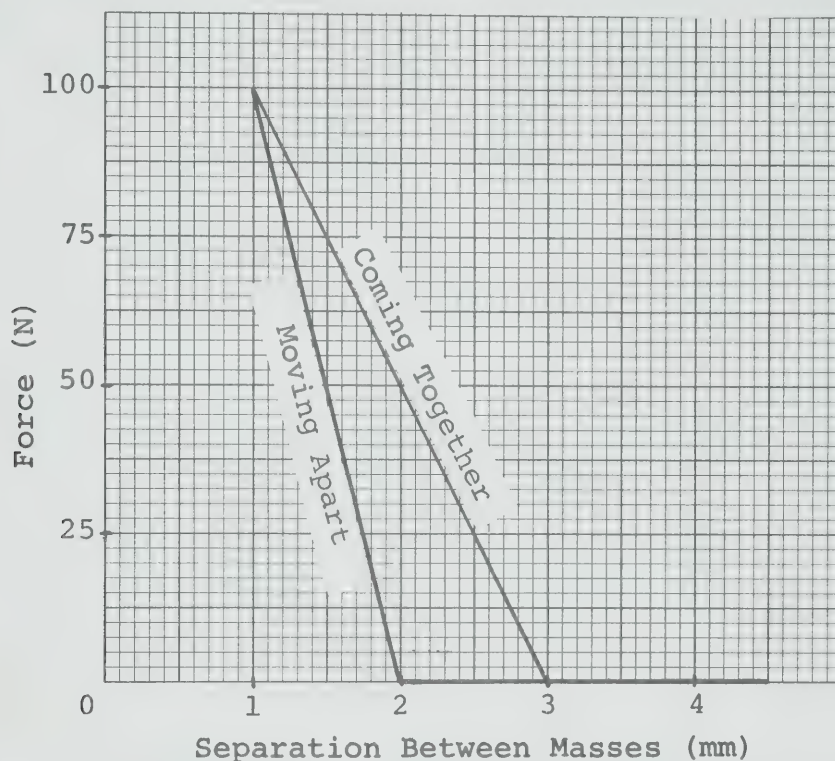
35

S17C
III.5.dS 54
S 42F1
A11

(C)

-

A wooden ball of mass m_1 moving with a velocity v_1 collides with a stationary steel ball of mass m_2 . The forces which the two balls exert on each other, as a function of their separation while they are coming together and going apart, are shown in the graph.



Which of the following statements is not correct for this collision?

- (A) Momentum is conserved at all times during the collision.
- (B) Energy is temporarily stored by the system.
- (C) 0.15 J of potential energy are gained by the system.
- (D) During the collision, the impulses delivered by the balls on each other are the same size.
- (E) 0.05 J of kinetic energy are lost by the system.

1 The watt is a unit of power.

S17A (A) True
I.3.b
S17C (B) False
III.5.b

S 48
S 46
S 41
S 35

A2
A3

(A)

-
*

2 The watt is a unit of energy.

S17A (A) True
I.3.b
S17C (B) False
III.5.b

S 48
S 46
S 41
S 35

A2
A3

(B)

-
*

3 The newton is a unit of mass.

S17A (A) True
I.3.a
S17C (B) False
III.5.b

S 49
S 46
S 41
S 35

A2
A3

(B)

-
*

4 The newton is a unit of force.

S17A (A) True
I.3.a
S17C (B) False
III.5.b

S 49
S 46
S 41
S 35

A2
A3

(A)

-
*

5 The newton is a unit of energy.

S17A (A) True
I.3.a
S17C (B) False
III.5.b

S 49
S 46
S 41
S 35

A2
A3

(B)

-
*

6 The work done by the centripetal force acting on a body during one half a revolution is zero.

S17C
III.5.a (A) True
50 (B) False

A3

(A)

-

7 A body moves in a circle at constant speed. The work done by the centripetal force on the body is zero.

S17C
III.5.a (A) True
50 (B) False

A3

(A)

-
**

8

The work done by the centripetal force acting on a body during one revolution of the body is zero.

S17C

III.5.a

(A) True

50

(B) False

A3

(A)

-

**

9

In a perfectly elastic interaction involving two objects, the force of interaction depends only on the separation of the objects.

S17C

III.5.c

(A) True

54

(B) False

A8

(A)

-

10

In a perfectly elastic interaction involving two objects, the force of interaction does not depend on the direction of motion of the objects relative to one another.

S17C

III.5.c

54

(A) True

A8

(B) False

(A)

-

11 In an elastic interaction involving two objects,
momentum is conserved.

S17C

III.5.c (A) True

54 (B) False

A8

(A)

-

*

12 In an elastic interaction involving two objects,
kinetic energy is conserved.

S17C

III.5.c (A) True

54 (B) False

A8

(A)

-

**

13 In an inelastic interaction involving two objects,
momentum is conserved.

S17C

III.5.c (A) True

54 (B) False

A8

(A)

-

**

14 In an inelastic interaction involving two objects, kinetic energy is conserved.

S17C

III.5.c

(A) True

54

(B) False

A8

(B)

-

**

15 In an inelastic interaction involving two objects, the force of interaction depends only on the separation of the objects.

S17C

III.5.c

(A) True

54

(B) False

A8

(B)

-

**

16 In an inelastic interaction involving two objects, the force of interaction does not depend on the direction of motion of the objects relative to one another.

S17C

III.5.c

54

(A) True

A8

(B) False

(B)

-

**

GRAVITATIONAL

POTENTIAL ENERGY

1

S17C

III.6.c

55

F1

A8

(C)

-

The bob of a pendulum consists of two masses X and Y attached together. Mass Y has four times the mass of X. The bob is pulled aside to a height h and released. At the bottom of its swing, mass Y separates from mass X. Neglect friction and the change in the centre of mass of the bob.

After separation, mass X completes the swing and returns to a height of

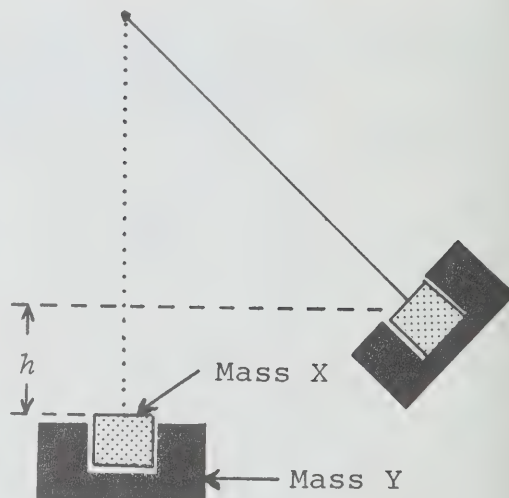
(A) $\frac{1}{5} h$

(B) $\frac{1}{4} h$

(C) h

(D) $4 h$

(E) $5 h$



2

A 0.20 kg rubber ball, initially at rest, is dropped from the window of a building. It strikes the sidewalk below with a speed of 30 m/s and rebounds from the sidewalk with a speed of 20 m/s. (Ignore any effect due to air friction.)

S17C
III.6.c

55

53

From what height was the ball dropped?

F1

(A) 125 m

(B)

(B) 45 m

-

(C) 30 m

**

(D) 25 m

(E) 20 m

3

A 0.20 kg rubber ball, initially at rest, is dropped from the window of a building. It strikes the sidewalk below with a speed of 30 m/s and rebounds from the sidewalk with a speed of 20 m/s. (Ignore any effect due to air friction.)

S17C
III.6.c

55

56

How much work is done by the gravitational force on the ball during the fall?

F1

(A) 90 J

(A)

(B) 40 J

-

(C) 9.0 J

(D) 6.0 J

(E) 3.0 J

4

S17C
III.6.d

Suppose a hole could be drilled straight down through the earth on the north-south axis of the earth. A stone is dropped into the north end of the hole.

S 55

F1

Which one of the following statements correctly describes the motion of the stone as it falls toward the centre of the earth?

(E)

(A) The velocity increases and the acceleration is constant.

(B) The velocity decreases and the acceleration is constant.

(C) The velocity increases and the acceleration increases.

(D) The velocity decreases and the acceleration increases.

(E) The velocity increases and the acceleration decreases.

5

S17C
III.6.b

A cross section of a frictionless downhill ski run shows the vertical height above the horizontal for various locations. A skier, whose mass is 75 kg, starts downhill at R. ($g = 10 \text{ m/s}^2$)

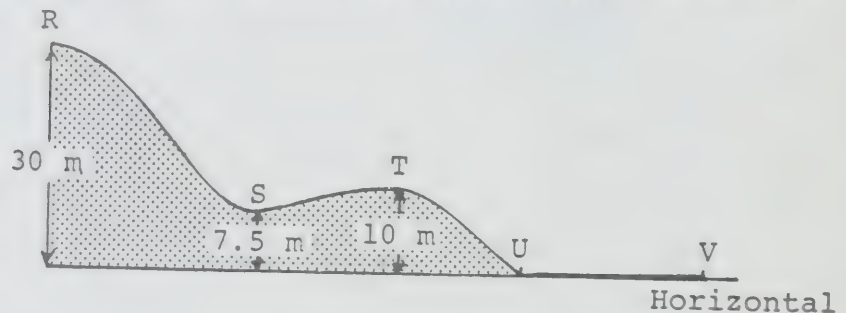
S 55

S 53

F1

A8

(E)



What is the kinetic energy of the skier at T?

(A) $8.0 \times 10^2 \text{ J}$

(B) $1.5 \times 10^3 \text{ J}$

(C) $7.5 \times 10^3 \text{ J}$

(D) $8.0 \times 10^3 \text{ J}$

(E) $1.5 \times 10^4 \text{ J}$

6

S17C

III.6.b

A cross section of a frictionless downhill ski run shows the vertical height above the horizontal for various locations. A skier, whose mass is 75 kg, starts downhill at R. ($g = 10 \text{ m/s}^2$)

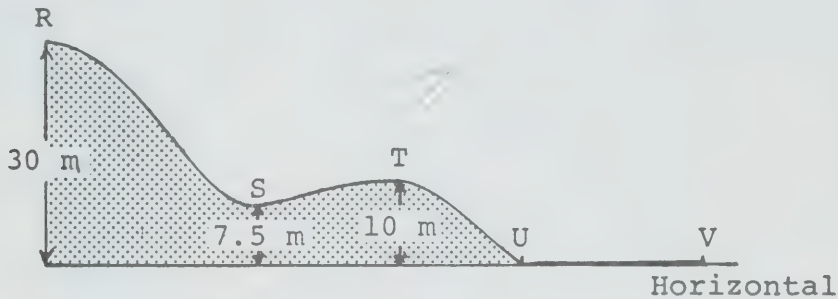
S 55

S 53

F1

A8

(B)

-

What is the speed of the skier at S?

(A) 14 m/s

(B) 21 m/s

(C) 23 m/s

(D) 25 m/s

(E) 35 m/s

7

S17C

III.6.c

The engine of a rocket exerts a constant force of F newtons upward on a rocket of mass m kilograms for a vertical distance of d metres, giving the rocket a velocity of v metres per second upward.

S 55

F1

A8

(D)

Which of the following expressions summarizes the total work done on the rocket? (Assume that g is constant.)

(A) $Fd = md$ (B) $Fd = mgd$ (C) $Fd = \frac{1}{2}mv^2$ (D) $Fd = \frac{1}{2}mv^2 + mgd$ (E) $Fd = \frac{1}{2}mv^2 - mgd$ -

8

S17C
III.6.a

S 55

F1

A8

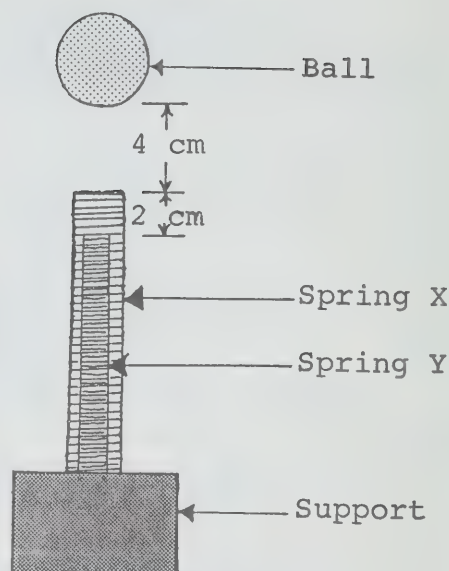
A5

A11

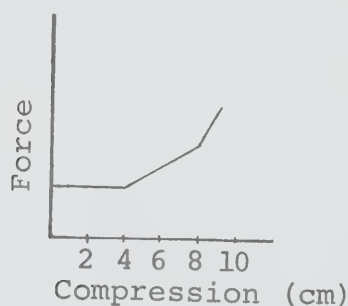
(E)

The diagram shows two springs, X and Y, having different force constants. The springs are arranged vertically with spring Y inside spring X. The upper end of spring Y is 2 cm below the upper end of spring X. The ball drops from a height of 4 cm above spring X and compresses spring X a total distance of 5 cm.

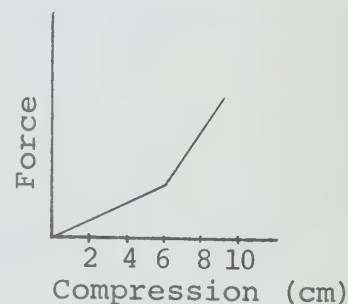
Neglecting the mass of the spring, which graph most closely represents the force-compression curve?



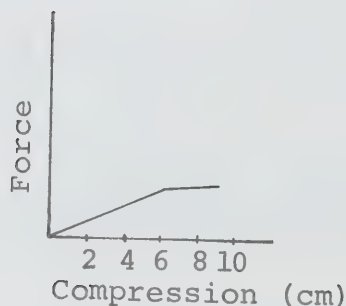
(A)



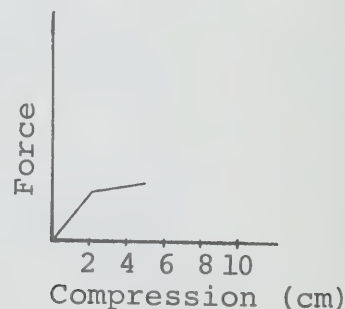
(B)



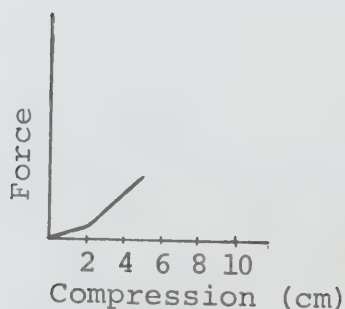
(C)



(D)



(E)



9

S17C
III.6.b

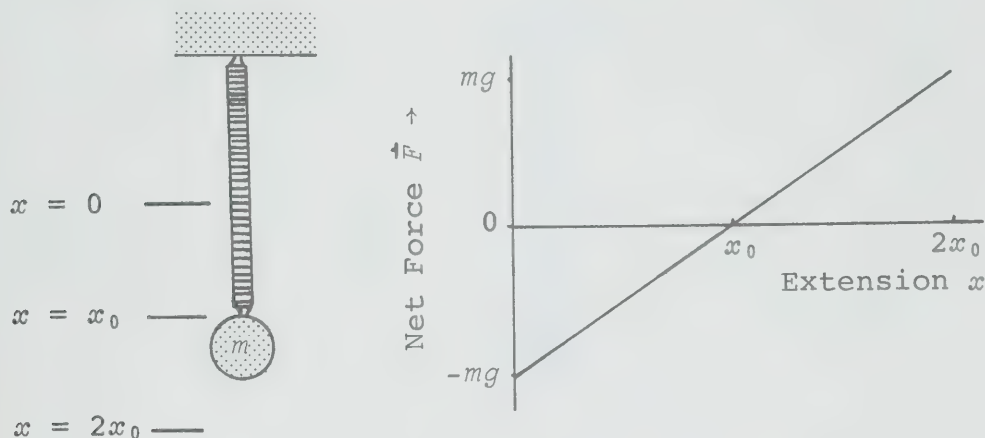
SS 55

F1
A8

(B)

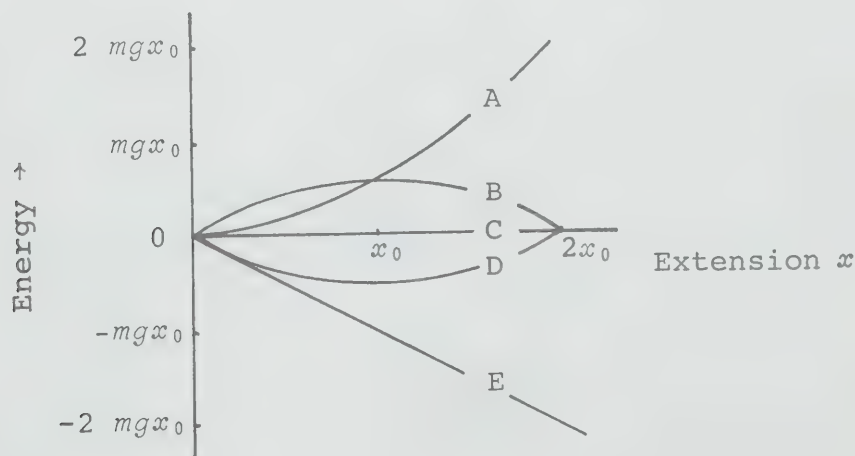
-

A mass m is suspended from a linear elastic spring. When the mass is at rest the spring has an extension of x_0 as shown. Two forces act on the mass, the force of gravity downward, and the tension of the spring upward. The graph below shows the net force $\vec{F}$ acting on the mass as a function of the extension x of the spring.



The mass is pulled down and allowed to oscillate between $x = 0$ and $x = 2x_0$. The zero of gravitational potential energy is taken at $x = 0$. Five graphs of energy versus extension are plotted on the same axis as shown below.

Which graph best represents the kinetic energy of the mass as a function of extension?



10

S17C

III.6.b

SS 55

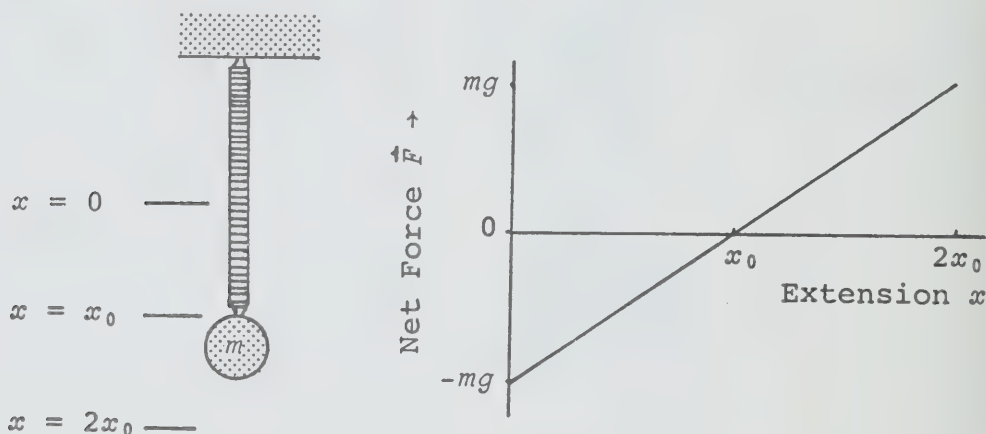
F1

A8

(E)

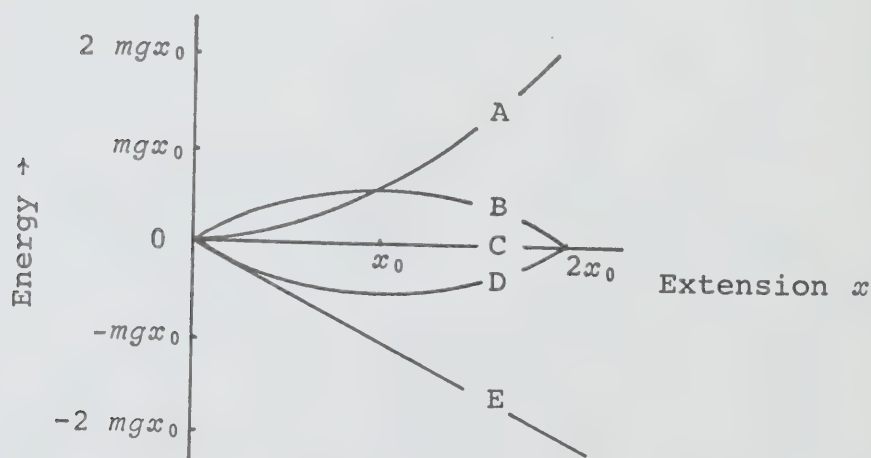
-

A mass m is suspended from a linear elastic spring. When the mass is at rest, the spring has an extension of x_0 as shown. Two forces act on the mass, the force of gravity downward, and the tension of the spring upward. The graph below shows the net force $\vec{F}$ acting on the mass as a function of the extension of the spring x .



The mass is pulled down and allowed to oscillate between $x = 0$ and $x = 2x_0$. The zero of gravitational potential energy is taken at $x = 0$. Five graphs of energy versus extension are plotted on the same axis as shown below.

Which graph best represents the gravitational potential energy as a function of extension?



11

S17C
III.6.b

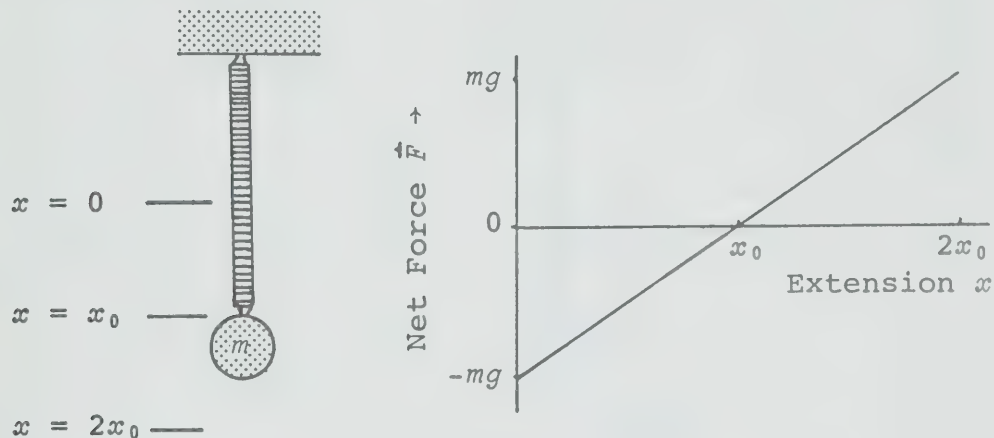
SS 55

F1
A8

(C)

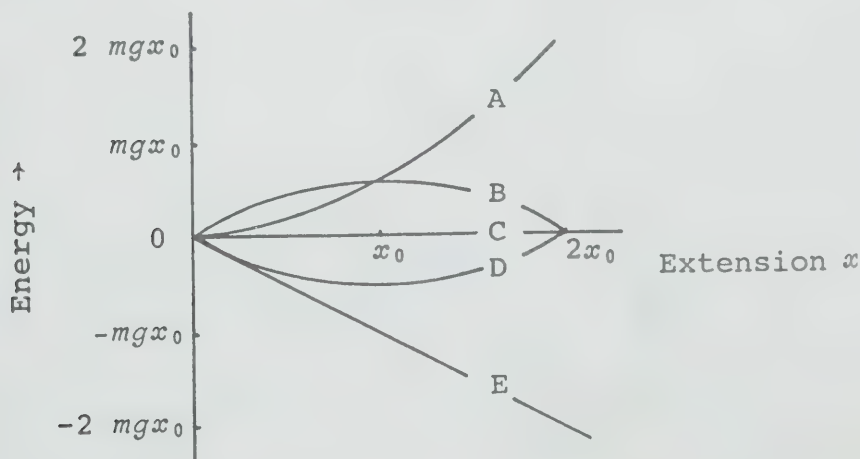
-

A mass m is suspended from a linear elastic spring. When the mass is at rest, the spring has an extension of x_0 as shown. Two forces act on the mass, the force of gravity downward, and the tension of the spring upward. The graph below shows the net force F acting on the mass as a function of the extension of the spring x .



The mass is pulled down and allowed to oscillate between $x = 0$ and $x = 2x_0$. The zero of gravitational potential energy is taken at $x = 0$. Five graphs of energy versus extension are plotted on the same axis as shown below.

Which graph best represents the total energy of the system as a function of extension?



12

S17C

III.6.b

SS 55

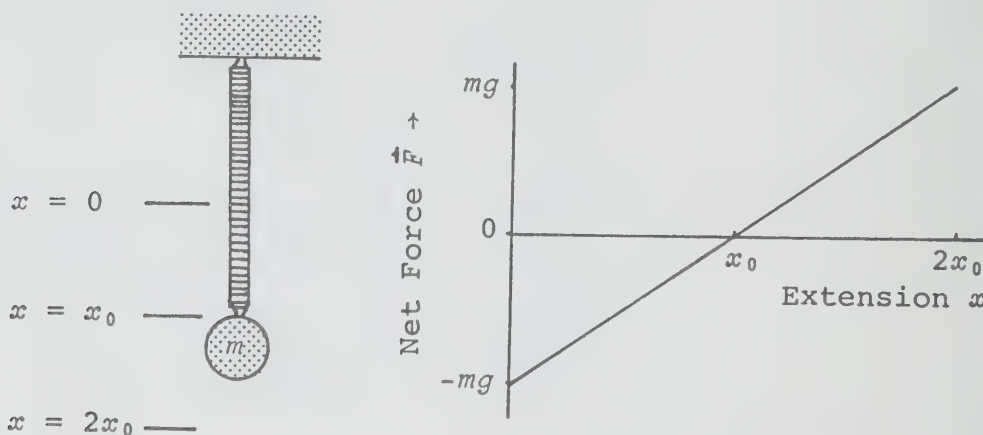
F1

A8

(D)

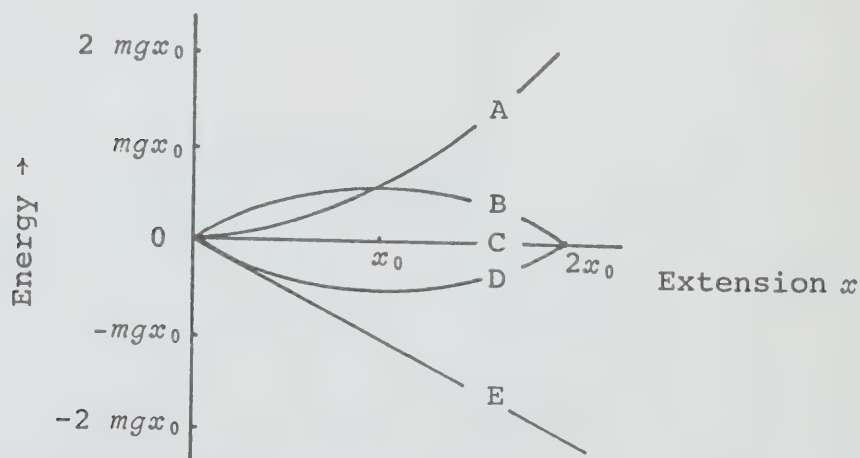
-

A mass m is suspended from a linear elastic spring. When the mass is at rest, the spring has an extension of x_0 as shown. Two forces act on the mass, the force of gravity downward, and the tension of the spring upward. The graph below shows the net force $\vec{F}$ acting on the mass as a function of the extension of the spring x .



The mass is pulled down and allowed to oscillate between $x = 0$ and $x = 2x_0$. The zero of gravitational potential energy is taken at $x = 0$. Five graphs of energy versus extension are plotted on the same axis as shown below.

Which graph best represents the sum of gravitational potential energy and elastic potential energy as a function of extension?



13

S17C

III.6.b

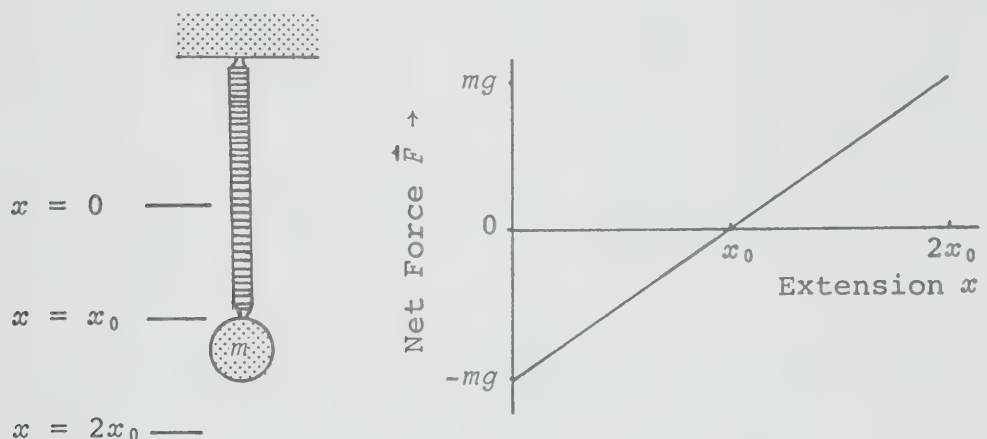
SS 55

F1

A8

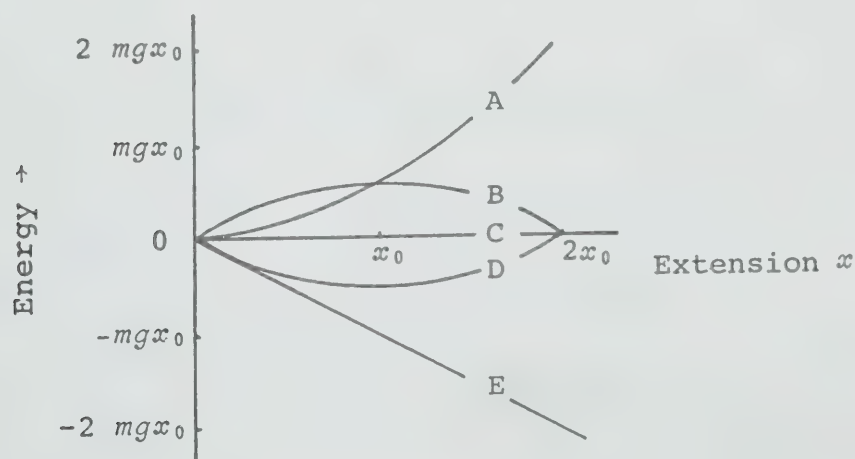
(A)

A mass m is suspended from a linear elastic spring. When the mass is at rest, the spring has an extension of x_0 as shown. Two forces act on the mass, the force of gravity downward, and the tension of the spring upward. The graph below shows the net force $\vec{F}$ acting on the mass as a function of the extension of the spring x .



The mass is pulled down and allowed to oscillate between $x = 0$ and $x = 2x_0$. The zero of gravitational potential energy is taken at $x = 0$. Five graphs of energy versus extension are plotted on the same axis as shown below.

Which graph best represents the elastic potential energy as a function of extension?



14

S17C
III.6.b

A crossbow archer wants to shoot an arrow of mass 0.02 kg to a vertical height of 50 m. The force constant k of the bow is 50 N/m.

SS 55

Assuming k remains constant, how far must the string in the bow be drawn back?

F1 (A) 0.20 m

(D) (B) 0.40 m

- (C) 0.45 m

(D) 0.63 m

(E) 1.6 m

15

S17C
III.6.f

Two identical lengths of smooth toy racing-car track are arranged as shown. They begin and end at the same heights, but are shaped in different ways. A friction-free car is rolled down each track in turn, starting from rest at the top.

56

E4

F3

(B)

**



A student claims correctly that the car will leave the bottom of both tracks at the same speed. Which one of these statements would support the student's claim?

- (A) The car travels the same distance along both tracks, so it must gain the same kinetic energy.
- (B) The change in potential energy of the car is the same on both tracks.
- (C) The average acceleration of the car is the same on both tracks.
- (D) The faster the car goes near the start, the less time it takes to cover later parts of the track.
- (E) The final momentum of the car is larger if the time of travel is longer.

16

S17C
III.6.f

56

E4
F3

(D)

**

Two identical lengths of smooth toy racing-car track are arranged as shown. They begin and end at the same heights, but are shaped in different ways. A friction-free car is rolled down each track in turn, starting from rest at the top.



A student claims correctly that the car will take a longer time to run down track (a) than track (b). Which one of these statements would support the student's claim?

- (A) The car travels the same distance along both tracks, so it must gain the same kinetic energy.
- (B) The change in potential energy of the car is the same on both tracks.
- (C) The average acceleration of the car is the same on both tracks.
- (D) The faster the car goes near the start, the less time it will take to cover later parts of the track.
- (E) The final momentum of the car is larger if the time to travel is longer.

17

S17C
III.6.f

S 56

A3

(E)

A ball is dropped from a certain height onto a concrete sidewalk.

When it bounces up again it does not quite reach the height from which it was dropped because

- (A) momentum is not conserved.
- (B) the ball momentarily stops during the impact.
- (C) the force of gravity slows down the ball.
- (D) the general law of conservation of energy is only approximately true.
- (E) some of the ball's energy is converted to heat energy.

18

This item involves two statements:

S17C
III.6.a

I. If a 10 N force causes a 5.0 cm extension in an elastic spring, then a 30 N force will cause a 15 cm extension.

S 56

F1

II. Hooke's Law states that the extension of an elastic spring is directly proportional to the applied force as long as the elastic limit has not been exceeded.

(A)

-
**

Which of the following responses correctly describes the two statements?

- (A) Both statements are true and one statement can be used to explain the other.
- (B) Both statements are true, but neither statement can be used to explain the other.
- (C) Statement I is true.
Statement II is false.
- (D) Statement I is false.
Statement II is true.
- (E) Statement I is false.
Statement II is false.

19

The mass of the earth is M , the mass of a satellite is m , and the gravitational constant is G .S17C
III.6.eWhat is the binding energy of the satellite if it is orbiting the earth in a circular orbit of radius r just above the atmosphere?

57

A8

(C)

-

(A) $\frac{GMm}{r}$

(B) $-\frac{GMm}{r}$

(C) $\frac{1}{2} \frac{GMm}{r}$

(D) $-\frac{1}{2} \frac{GMm}{r}$

(E) $\frac{GMm}{r^2}$

20

S17C
III.6.f

S 57

A3

A11

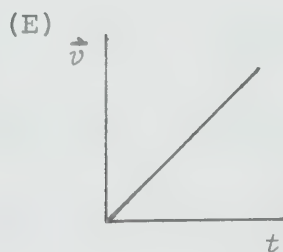
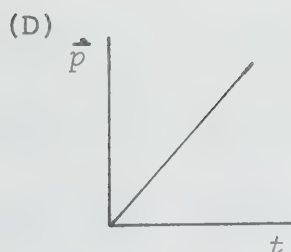
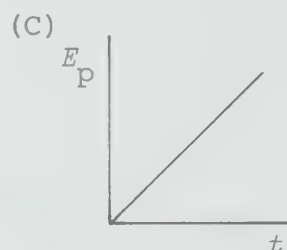
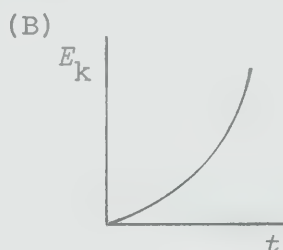
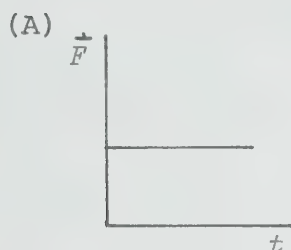
(C)

-

The physical quantities represented by the symbols on the graphs below are net force $\vec{F}$, kinetic energy E_k , potential energy E_p , momentum $\vec{p}$, and velocity $\vec{v}$.

When a small rocket is launched from the earth, the engines burn for a short time interval Δt . During this time a constant thrust is exerted. Assume that there is no change in the force of gravity on the rocket and that the mass of the rocket is constant.

Select the one graph below that does not apply to the rocket's motion during the time interval Δt .



21

S17C

III.6.f

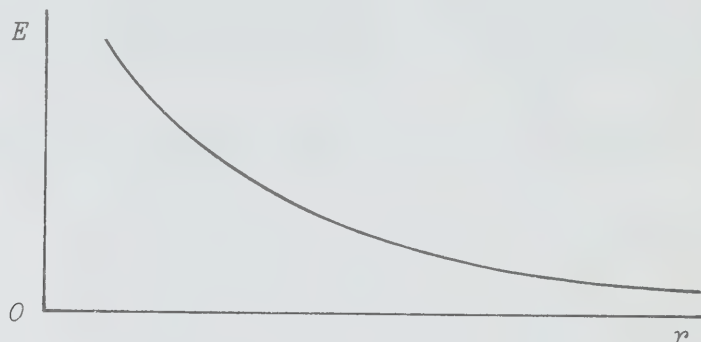
S 57

A10

(B)

-

Two magnetic dry ice pucks, X and Y, repel one another. The moving puck X is approaching the stationary puck Y on a horizontal frictionless surface. The following graph shows the stored magnetic energy E as a function of separation r between the pucks.



The height of the curve at any separation r is a direct measure of

- (A) the gain in the kinetic and potential energy of the system.
- (B) the decrease in the kinetic energy of the system.
- (C) the increase in the kinetic energy of the puck Y.
- (D) the decrease in the kinetic energy of the puck X.
- (E) the decrease in the total energy of the system.

22S17C
III.6.e

An empty space vehicle, launched with an initial velocity of 1.12×10^4 m/s, has just enough energy to escape the earth's gravitational field.

S 57

F1

What must be the initial velocity of a loaded space craft, which has triple the mass of the empty craft, so that it will also have sufficient energy to escape? Ignore air friction.

(B)

(A) 3.73×10^3 m/s

-

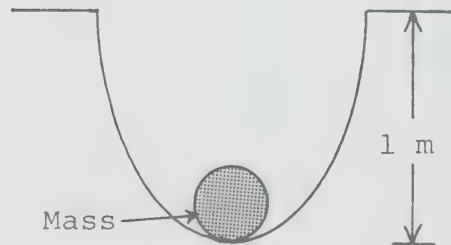
(B) 1.12×10^4 m/s(C) 3.36×10^4 m/s(D) 9.98×10^4 m/s(E) 3.36×10^{12} m/s**23**S17C
III.6.e

S 57

F1

A8

A mass of 1 kg is free to slide with no friction in a well 1 m deep. It is given an initial speed of 4 m/s at the bottom of the well causing it to oscillate from side to side.



(B)

Which of the following statements is true?

-

(A) The total energy of the mass, with reference to the top of the well, is 2 J.

(B) The binding energy of the mass is 2 J.

(C) The escape speed of the mass from the well is 5 m/s.

(D) The oscillating mass reaches a maximum height of 0.2 m from the bottom of the well.

(E) The kinetic energy of the mass at the bottom of the well is 2 J.

24

The graph shows the rate of fuel consumption for a three stage rocket.

S17C

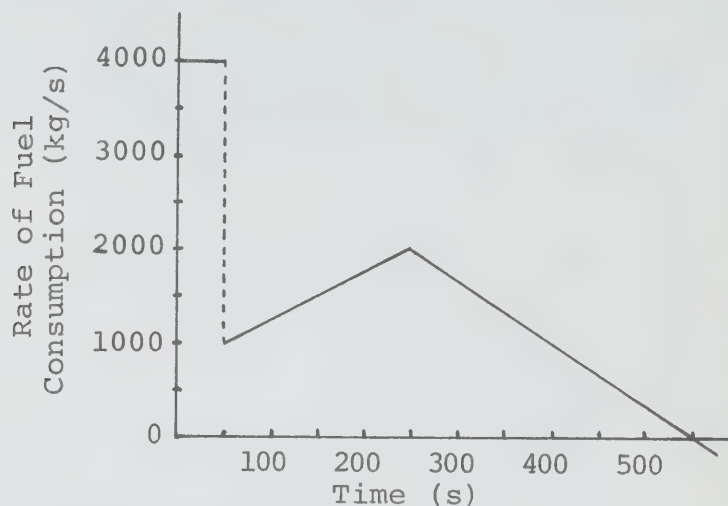
III.6.e

S 57

F1

A7

(C)

-
***

How many kilograms of fuel were used during the second stage of the flight?

- (A) 1.0×10^5
- (B) 2.0×10^5
- (C) 3.0×10^5
- (D) 5.0×10^5
- (E) 8.0×10^5

25

S17C
III.6.b

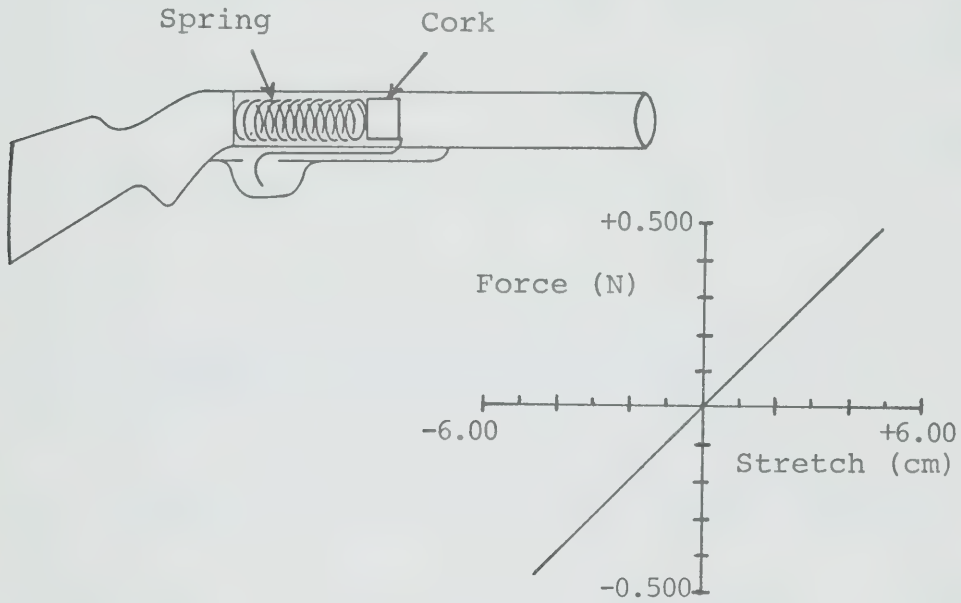
SS 57

F1
All

(C)

-

The graph shows the force as a function of stretch for the cork gun containing an ideal light spring as shown below. The spring is compressed to -5.00 cm and used to propel a cork of mass 6.00 g from the gun. The cork, however, sticks to the spring causing the spring to extend 1.00 cm beyond its unstretched length before separation occurs.



What is the speed of the cork at the time of release?

- (A) 1.02 m/s
- (B) 1.41 m/s
- (C) 2.00 m/s
- (D) 2.04 m/s
- (E) 4.00 m/s

26S17C
III.6.e

A rocket is launched from the earth and travels to the upper limit of the earth's atmosphere. At this point its kinetic energy is 0.5×10^{10} J and its potential energy is -0.6×10^{10} J.

SS 57

Which of the following statements is true?

F1

(E)

-

- (A) The vehicle will escape and its binding energy is 1.1×10^{10} J.
- (B) The vehicle will escape and its binding energy is 0.1×10^{10} J.
- (C) The vehicle will escape and have a kinetic energy after escape of 0.1×10^{10} J.
- (D) The vehicle will escape and have a binding energy of -0.1×10^{10} J.
- (E) The vehicle will not escape because it has a binding energy of 0.1×10^{10} J.

27S17C
III.6.a

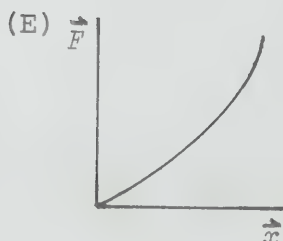
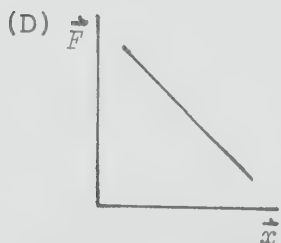
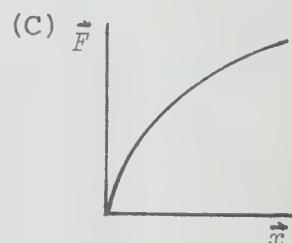
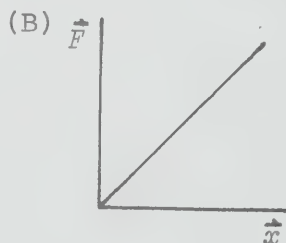
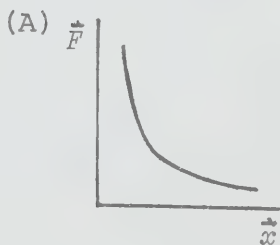
On the following graphs the force $\vec{F}$ on a spring is plotted against the extension $\vec{x}$ of the spring.

Which graph correctly illustrates Hooke's Law?

SS 57

A5
A11
D3

(B)

-
**

1S17C
III.3.b

Suppose a hole could be drilled straight down through the earth on the north-south axis of the earth. A stone is dropped into the north end of the hole.

S 55

As the stone falls towards the centre of the earth, the unbalanced force acting on the stone increases.

F1

(A) True

(B)

(B) False

-

2S17C
III.3.b

Suppose a hole could be drilled straight down through the earth on the north-south axis of the earth. A stone is dropped into the north end of the hole.

S 55

As the stone falls towards the centre of the earth, the unbalanced force acting on the stone decreases.

F1

(A) True

(A)

(B) False

-

3S17C
III.3.b

Suppose a hole could be drilled straight down through the earth on the north-south axis of the earth. A stone is dropped into the north end of the hole.

S 55

As the stone falls towards the centre of the earth, the unbalanced force acting on the stone is constant.

F1

(A) True

(B)

(B) False

-

- 4 Suppose a hole could be drilled straight down through the earth on the north-south axis of the earth. A stone is dropped into the north end of the hole.
- S17C
III.6.d
- S 55 As the stone falls towards the centre of the earth, the magnitude of the potential energy of the stone increases.
- F1
- (B) (A) True
- (B) False
- ***

- 5 Suppose a hole could be drilled straight down through the earth on the north-south axis of the earth. A stone is dropped into the north end of the hole.
- S17C
III.6.d
- S 55 As the stone falls towards the centre of the earth, the magnitude of the potential energy of the stone decreases.
- F1
- (A) (A) True
- (B) False
- ***

- 6 Suppose a hole could be drilled straight down through the earth on the north-south axis of the earth. A stone is dropped into the north end of the hole.
- S17C
III.6.d
- S 55 As the stone falls towards the centre of the earth, the magnitude of the potential energy of the stone is constant.
- F1
- (B) (A) True
- (B) False
- ***

7S17C
III.3.b

Suppose a hole could be drilled straight down through the earth on the north-south axis of the earth. A stone is dropped into the north end of the hole.

S 55

As the stone falls towards the centre of the earth, the acceleration of the stone increases.

F1

(A) True

(B)

(B) False

-

8S17C
III.3.b

Suppose a hole could be drilled straight down through the earth on the north-south axis of the earth. A stone is dropped into the north end of the hole.

S 55

As the stone falls towards the centre of the earth, the acceleration of the stone decreases.

F1

(A) True

(A)

(B) False

-

9S17C
III.3.b

Suppose a hole could be drilled straight down through the earth on the north-south axis of the earth. A stone is dropped into the north end of the hole.

S 55

As the stone falls towards the centre of the earth, the acceleration of the stone is constant.

F1

(A) True

(B)

(B) False

-

10 Hooke's Law is obeyed only by springs which are compressed.

S17C

III.6.a (A) True

SS 57 (B) False

A1

A8

(B)

-

**

11 When a spring is compressed, it does not obey Hooke's Law.

S17C

III.6.a (A) True

SS 57 (B) False

A1

A8

(B)

-

**

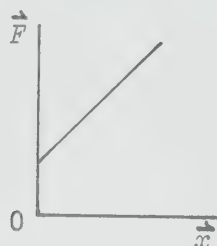
- 12** Consider the following force-displacement graph for a spring.

S17C
III.6.a

SS 57

A8

(B)



—
*** The spring described by this graph obeys Hooke's Law.

- (A) True
(B) False

- 13** Consider the following force-displacement graph for a spring.

S17C
IV.6.a

SS 57

A8

(A)



—
** The spring described by this graph obeys Hooke's Law.

- (A) True
(B) False

B E H A V I O U R O F L I G H T

A N D

M O D E L S O F L I G H T

GEOMETRIC OPTICS

1

S17A

II.3.a

S17C

II.1.b

In an experiment involving the travel of light from water into glass, measurements of the angle of refraction R were recorded for various values of the angle of incidence i ranging from 0° to 90° .

Which one of the following graphs of R against i best represents the experimental results?

S 60

S 285

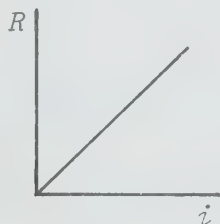
A5

A8

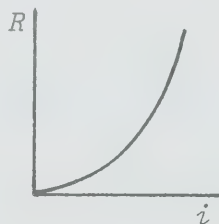
A11

(E)

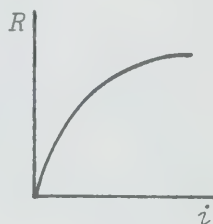
(A)



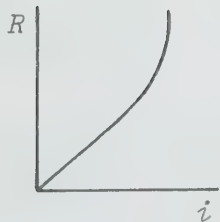
(B)



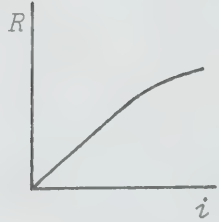
(C)



(D)



(E)



2

A metre stick is immersed approximately half way in a tank of water.

S17A

II.3.a

S17C

II.1.b

The apparent bending of the metre stick at the boundary between air and water is caused by

(A) refraction.

60

(B) reflection.

A1

F1

(C) diffraction.

(A)

(D) interference.

-

*

(E) a combination of (B) and (C).

3

Which diagram below best illustrates the path a light ray travels between the fixed points X in air and Y in glass?

S17A

II.3.a

S17C

II.1.b

S 60

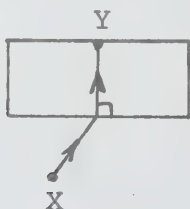
F1

A3

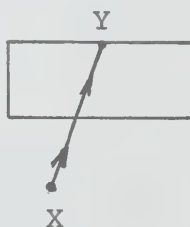
(E)

-

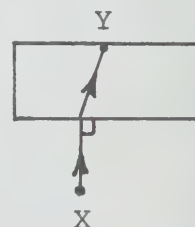
(A)



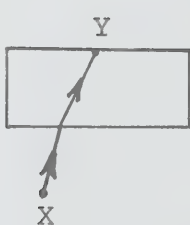
(B)



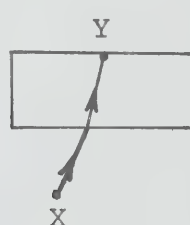
(C)



(D)



(E)



PARTICLE MODEL OF LIGHT

- 1** Newton assumed that light consists of particles.
Some postulated properties of these particles are listed below.
- S17C
II.2.b
- 63 Which of these properties is needed to account for
64 the fact that light does not slow down when it is reflected?
- E3 (A) They travel at very high speeds.
I3 (B) They make elastic collisions.
(B) (C) They have a very small mass.
- (D) They are small compared to the spaces between
** them.
(E) They are affected by gravitational forces.

- 2** Newton assumed that light consists of particles.
Some postulated properties of these particles are listed below.
- S17C
II.2.b
- 63 Which one of these properties is needed to account
for the fact that the two light beams are able to
pass through each other without any apparent
scattering?
- E3 (A) They travel at very high speeds.
I3 (B) They make elastic collisions.
(D) (C) They have a very small mass.
- (D) They are small compared to the spaces between
** them.
(E) They are affected by gravitational forces.

3

The particle theory of light satisfactorily accounts for

S17C

II.2.d

(A) diffraction.

64

(B) interference.

A9

(C) partial reflection and refraction.

(E)

(D) polarization.

-

(E) reflection.

4

This item involves two statements:

S17C

II.1.a

I. As you move away from a light source the intensity of the light decreases.

67

II. There is an inverse square law relationship between the intensity of light and the distance from the light source.

A8

(A)

Which of the following responses correctly describes the two statements?

-

*

(A) Both statements are true and one statement can be used to explain the other.

(B) Both statements are true, but neither statement can be used to explain the other.

(C) Statement I is true.
Statement II is false.

(D) Statement I is false.
Statement II is true.

(E) Statement I is false.
Statement II is false.

5

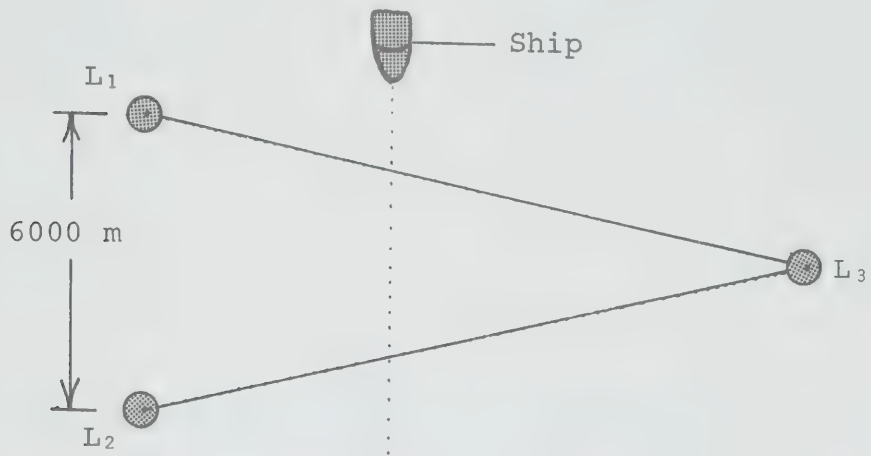
S17C
II.6.d

A ship is navigating by using the light from three identical lighthouses L_1 , L_2 , and L_3 . L_3 is equidistant from L_1 and L_2 and the distance L_1L_2 is 6000 m, as shown. The diagram is not drawn to scale.

S 67

F1
A8

(C)

-
****

When the ship crosses the line L_1L_3 it is observed that the intensity of light from L_1 is four times that of L_3 . Sailing on a steady bearing and with no current, the ship next crosses the line L_2L_3 and again finds the intensity of L_2 to be 4 times that of L_3 .

How far did the ship travel between the two intensity readings?

- (A) 9000 m
- (B) 4800 m
- (C) 4000 m
- (D) 1500 m
- (E) 1200 m

1 According to the simple particle model, Snell's Law does not apply to the refraction of particles.

S17C

II.2.d

(A) True

65

(B) False

A1

(B)

-

**

2 According to the simple particle model, when particles are refracted $\frac{\sin i}{\sin R}$ is a constant.

S17C

II.2.d

(A) True

65

(B) False

A10

(A)

-

**

3 The particle model of light predicts that light slows down when it travels from air into glass.

S17C

II.2.e

(A) True

65

(B) False

E3

A1

(B)

-

4

According to the simple particle model, the speed of the particles decreases as the particles are refracted toward the normal.

S17C
II.2.e

(A) True

68

(B) False

A1

(B)

-

5

According to the simple particle model, when particles are refracted toward the normal they speed up.

S17C
II.2.e

(A) True

68

(B) False

A1

(A)

-

**

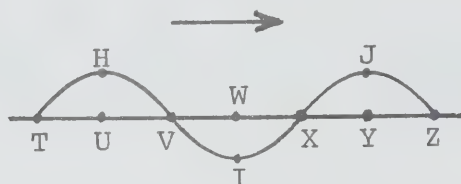
CHARACTERISTICS AND BEHAVIOURS OF WAVES

1

The wave disturbance shown below is travelling from left to right through a medium.

Sl7A
II.1.c
Sl7C
II.4.b

S 69



A1

What is the direction of the instantaneous velocity of a particle of the medium located at point V?

(A)

-

(A) 

(B) 

(C) 

(D) 

(E) There is no direction since the velocity is zero.

2

S17A

II.1.b

S17C

II.3.b

S 69

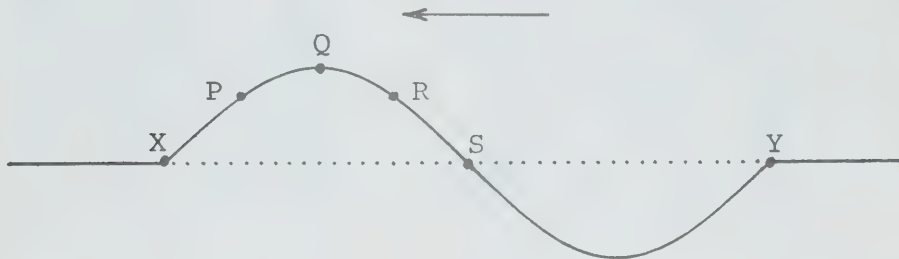
A10

A1

(B)

-

The diagram below shows a portion of a string in which a wave XY travels in the direction indicated by the arrow.



Consider the following statements about the string at this instant:

- I. Point P is moving upward.
- II. Point Q is moving downward.
- III. Point R is moving downward.
- IV. Point S is stationary.

Which of these statements are correct?

- (A) I and II only
- (B) I and III only
- (C) II and III only
- (D) II and IV only
- (E) I, II and IV only

3

S17C
II.4.c

70

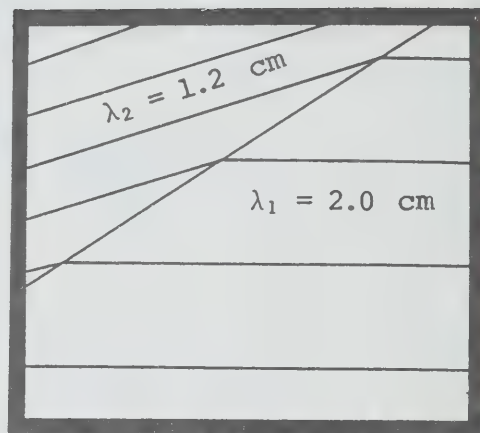
F1

A8

(D)

-
**

The ripple tank shown has deep and shallow water sections. The wavelength λ_1 of the water waves in the deep water is 2.0 cm. The wavelength λ_2 of the water waves in the shallow water is 1.2 cm. The ripple generator has a frequency of 12 Hz.



The speed of the water waves in the shallow water is closest to

- (A) 1.2 cm/s
- (B) 10 cm/s
- (C) 12 cm/s
- (D) 14 cm/s
- (E) 24 cm/s

4

S17C
II.4.c

70

F1

A8

(E)

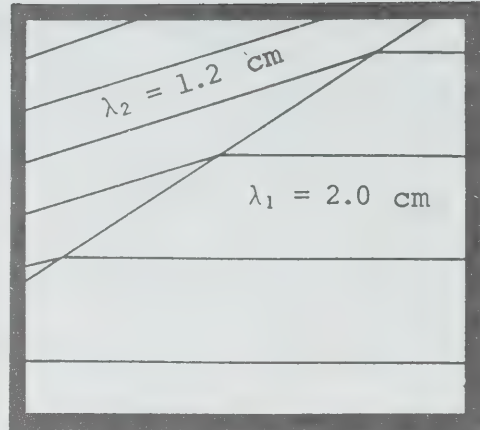
-

**

The ripple tank shown has deep and shallow water sections. The wavelength λ_1 of the water waves in the deep water is 2.0 cm. The wavelength λ_2 of the water waves in the shallow water is 1.2 cm. The ripple generator has a frequency of 12 Hz.

The speed of the water waves in the deep water is

- (A) 2.0 cm/s
- (B) 6.0 cm/s
- (C) 12 cm/s
- (D) 14 cm/s
- (E) 24 cm/s



5

A large stationary source is generating water waves having a frequency of 5.0 Hz and a speed of 2.0 m/s. A boat is approaching the source at a speed of 10 m/s.

S17A
II.1.c
S17C
II.4.b

What is the apparent frequency of the water waves to an observer in the boat?

- S 70 (A) 5.0 Hz
F1 (B) 15 Hz
(E) (C) 20 Hz
- (D) 25 Hz
*** (E) 30 Hz

6

Two different depth regions X and Y are separated from one another in a ripple tank by the boundary GH as shown. Solid lines in the tank represent wave fronts.

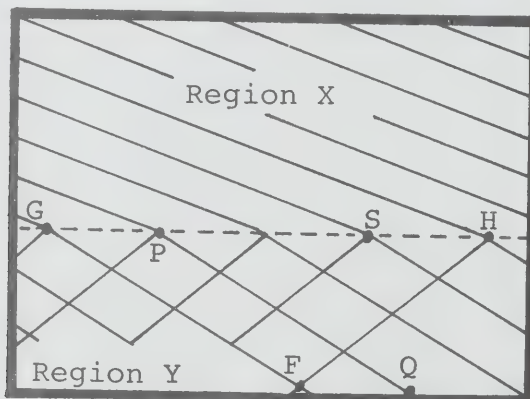
S17C
II.4.c

72

A1

(D)

-



Which of the following statements is correct?

- (A) FH is an incident wave front.
(B) Region Y is shallower than region X.
(C) PQ is a reflected wave front.
(D) Waves in region X have the same frequency as waves in region Y.
(E) The intersection points in region Y represent nodes.

7

Water waves generated in a ripple tank are refracted on going from deep water to shallow water.

S17C

II.4.c

Which one of the following factors will not affect the amount of bending?

72

A1

(A) the angle the incident wave front makes with the boundary

(D)

(B) the difference in depth between the two regions

-

(C) the wavelength of the wave

(D) the amplitude of the wave

(E) the frequency of the wave

8

How can diffraction by a single slit in a ripple tank be decreased?

S17C

II.4.d

(A) Increase the frequency of the waves.

S 74

(B) Increase the amplitude of the waves.

F1

(C) Decrease the width of the slit.

(A)

(D) Decrease the distance between the wave generator and the slit.

-

(E) Use a longer wavelength.

INTERFERENCE OF PERIODIC WAVES

1

S17A
II.1.d
S17C
II.5.a

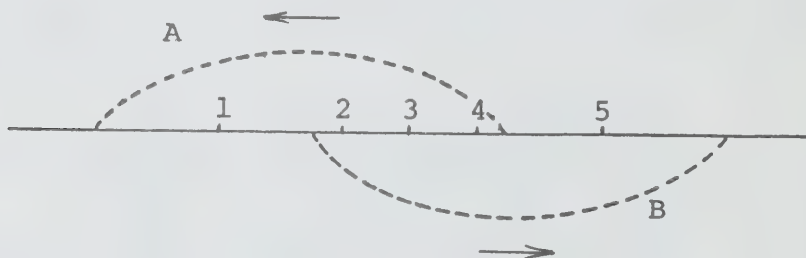
75

A8
F1

(D)

-
**

Points 1, 2, 3, 4, and 5 are marked on a stretched cord. Pulses A and B, which have the same shape and size, are travelling through this cord at the same speed.



Which point(s) would have no motion, provided the pulses were moving in opposite directions?

- (A) points 1 and 2 only
- (B) points 2, 3, and 4 only
- (C) points 4 and 5 only
- (D) point 3 only
- (E) none of the above choices

2

S17A
II.1.d
S17C
II.5.a

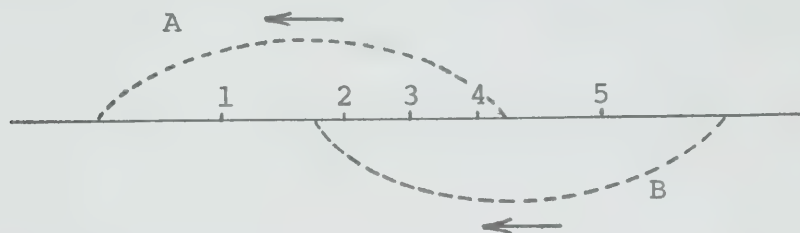
75

A8
F1

(B)

-

Points 1, 2, 3, 4, and 5 are marked on a stretched cord. Pulses A and B, which have the same shape and size, are travelling through this cord at the same speed.



Which point(s) would have an instantaneous downward motion if both pulses were moving to the left?

- (A) points 1 and 2 only
- (B) points 2, 3, and 4 only
- (C) points 4 and 5 only
- (D) point 3 only
- (E) none of the above choices

3

S17A
II.1.d
S17C
II.5.a

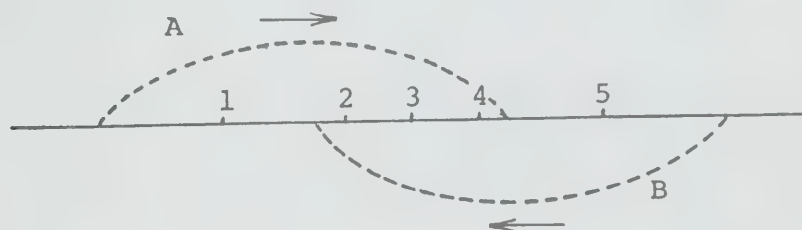
75

A8
F1

(A)

-

Points 1, 2, 3, 4, and 5 are marked on a stretched cord. Pulses A and B, which have the same shape and size, are travelling through this cord at the same speed.



Which point(s) would have an instantaneous downward motion if pulse A were moving to the right as pulse B moved to the left?

- (A) points 1 and 2 only
- (B) points 2, 3 and 4 only
- (C) points 4 and 5 only
- (D) point 3 only
- (E) none of the above choices

4

S17A
II.1.d
S17C
II.5.a

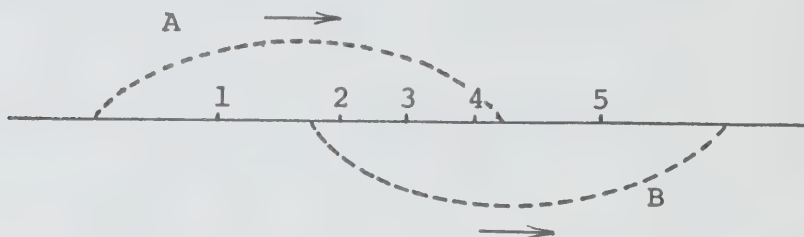
75

A8
F1

(B)

-

Points 1, 2, 3, 4, and 5 are marked on a stretched cord. Pulses A and B, which have the same shape and size, are travelling through this cord at the same speed.



Which point(s) would have an instantaneous upward motion if both pulses were moving to the right?

- (A) points 1 and 2 only
- (B) points 2, 3, and 4 only
- (C) points 4 and 5 only
- (D) point 3 only
- (E) none of the above choices

5

S17C
II.3.b

SS 75

F1

(A)

-

One end of a copper coil spring is connected to the end of a steel coil spring of the same length to produce a combination coil spring. A pulse sent from one end of the combination produces two distinct reflected pulses, one from the junction and one from the far end. The first reflected pulse returns 0.60 s after the pulse is sent down the combination. The second reflected pulse returns 1.1 s after the pulse is sent down the combination.

Which one of the following statements is definitely true?

- (A) The first section of the coil is the lower velocity medium.
- (B) The first reflected pulse is inverted.
- (C) The second reflected pulse is inverted.
- (D) The second section of the coil has the larger diameter.
- (E) Neither reflected pulse is inverted.

6

A point is one half a wavelength farther from one source than from another identical source.

S17C

II.5.a

If the two sources are in phase, there is

78

(A) constructive interference of the waves.

A2

(B) destructive interference of the waves.

A1

(C) no interaction between the waves.

(B)

(D) both constructive and destructive interference at the same time.

-

(E) constructive interference followed by destructive interference at regular intervals.

7

Two small loudspeakers are arranged 30 cm apart on an east-west line directing sounds towards the north. Both speakers produce sounds of exactly the same frequency and always vibrate in phase with each other. A microphone is located 40 cm due north of one speaker.

S17C

II.5.a

S 78

S 152

The sound intensity at the microphone is greatest when the wavelength of the sound is

F1

(A)

(A) 10 cm

-

(B) 20 cm

(C) 30 cm

(D) 40 cm

(E) 70 cm

8

S17C
II.5.a

S 79

F1

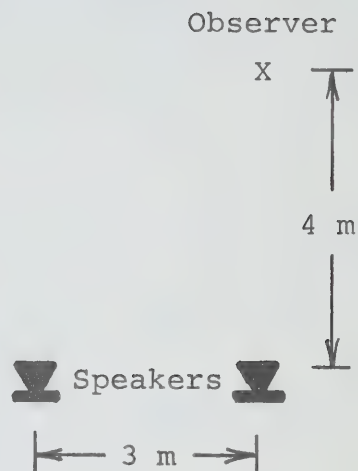
(B)

Two small identical speakers, connected to the same frequency source, are arranged 3 m apart at ear level above the floor. An observer stands at position X, 4 m directly in front of one of the speakers.

-

To the observer, the sound intensity will be least when the wavelength is

- (A) 1 m
- (B) 2 m
- (C) 3 m
- (D) 4 m
- (E) 5 m



9

S17C
II.5.a

S 79

F1

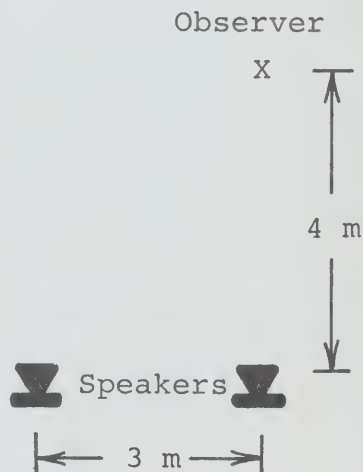
(E)

Two small identical speakers, connected to the same frequency source, are arranged 3 m apart at ear level above the floor. An observer stands at position X, 4 m directly in front of one of the speakers.

-

To the observer, the sound intensity will be greatest when the wavelength is

- (A) 5 m
- (B) 4 m
- (C) 3 m
- (D) 2 m
- (E) 1 m



WAVE MODEL OF LIGHT AND INTERFERENCE

1 The reflection of incoming radio waves by a radio telescope dish is similar in behaviour to the reflection of

S17A
II.3.a
S17C
II.4.a

(A) straight waves from a straight barrier

(B) straight waves from a concave barrier

81
71 (C) straight waves from a convex barrier

E3 (D) circular waves from a straight barrier

(B) (E) circular waves from a concave barrier

-

2 The absolute index of refraction of substance P is 2.4, and of substance Q is 1.2.

S17C
II.6.d

The relative index of refraction for light going from P to Q is

82 (A) 0.50

F1
A8 (B) 1.2

(A) (C) 2.0

- (D) 2.9

*** (E) 3.6

3

Four materials, with their symbols and indexes of refraction, are shown in the table.

S17C

II.1.b

S 82

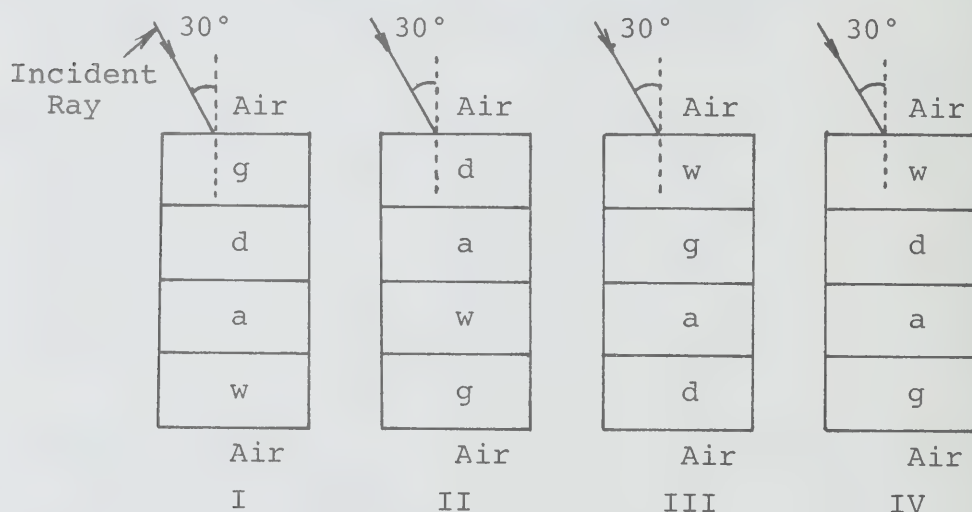
F1

(E)

Material	Symbol	Index of Refraction
air	a	1.0
diamond	d	2.4
glass	g	1.5
water	w	1.3

—
**

The four materials are placed in layers in different arrangements. A ray of light strikes the top surface of each arrangement at an angle of incidence of 30° as shown below.



In which of the arrangements will the emergent ray have an angle of emergence of 30° ?

- (A) I only
- (B) II only
- (C) III only
- (D) IV only
- (E) all four

4

S17C
II.4.c

S 82

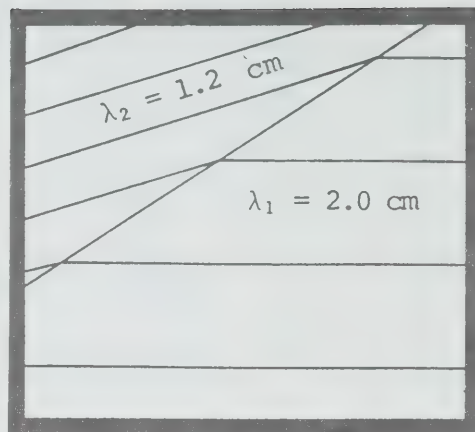
F1

A8

(C)

-
**

The ripple tank shown has deep and shallow water sections. The wavelength λ_1 of the water waves in the deep water is 2.0 cm. The wavelength λ_2 of the water waves in the shallow water is 1.2 cm. The ripple generator has a frequency of 12 Hz.



The relative index of refraction for water waves travelling from deep water to shallow water is

- (A) 0.60
- (B) 0.80
- (C) 1.7
- (D) 2.4
- (E) 3.2

5

S17C
II.6.d

84

A8

(B)

-

The fact that we cannot see an interference pattern from the filaments of two small light bulbs which are close together is due to the

- (A) very high velocity of light waves.
- (B) random phase differences between light waves from the two sources.
- (C) air molecules diffracting the light waves coming from the two sources.
- (D) very short wavelengths of light waves.
- (E) inability of our eyes to resolve two sources close together.

6

In 1802, Thomas Young performed his double slit experiment to demonstrate the interference of light.

S17C

II.6.a

Which of the following statements concerning this experiment is not true?

S 84

A1

(C)

-

(A) Diffraction of light occurs at the slits.

(B) Light waves leaving the two slits have a fixed phase difference.

(C) The interference pattern from this experiment has a nodal line at the centre of the pattern.

(D) The separation of the nodal lines is dependent on the wavelength of the light.

(E) The particle theory of light was unable to give a satisfactory explanation of this phenomenon.

7

Light from an incandescent source passes through a red filter, then through two narrow slits close together, and finally into the observer's eye.

S17C

II.6.a

The equidistant black bands seen by the observer are due to

S 84

A1

A2

(D)

-

**

(A) the red filter.

(B) crests and troughs in the transverse waves.

(C) polarization.

(D) interference.

(E) diffraction.

8

Which of the following properties of light is Young's experiment designed to demonstrate?

S17C

IV.6.b

(A) diffraction

S 84

(B) dispersion

A1

(C) graininess

(D)

(D) interference

-

(E) polarization

9

Monochromatic red light is shone from above on two soap films X and Y. An observer, looking down at the soap films, observes that film X appears uniformly red while film Y has alternate, equally spaced, red and black bands.

S17C

II.6.c

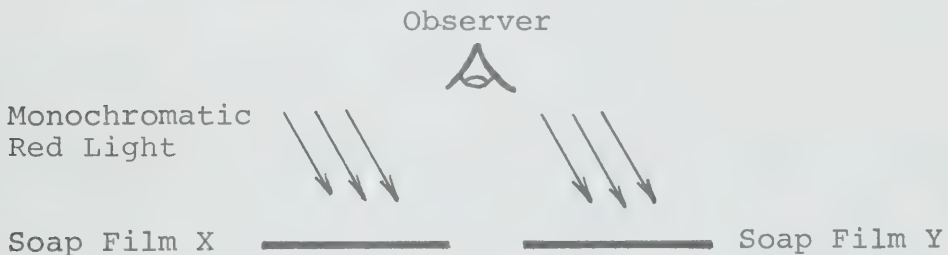
S 84

F1

(D)

Monochromatic
Red Light

-



Which is the best explanation for the difference in appearance of the two films?

(A) Film X has a thickness of $\frac{1}{4} \lambda$ and film Y has a thickness of $\frac{1}{2} \lambda$.

(B) Film X has a thickness of $\frac{1}{2} \lambda$ and film Y has a thickness of $\frac{1}{4} \lambda$.

(C) Film X has a thickness much less than λ and film Y has a thickness of $\frac{1}{2} \lambda$.

(D) Film X has a constant thickness and film Y has a variable thickness.

(E) Film X has a variable thickness and film Y has a constant thickness.

10

S17C
II.5.a

A student performs an interference experiment with two point sources vibrating in phase. The student verifies that the path difference from each source to a point on a nodal line is correctly given by the expression $d \sin \theta$.

85

A1

Which one of the following conditions must be true for the success of this experiment?

(C)

(A) The waves are of high frequency.

-

(B) The number of nodal lines is low.

(C) The point is far away compared to the spacing of the sources.

(D) The sources are close together.

(E) The waves are of short wavelength.

11

S17C
II.6.a

A monochromatic light source is placed directly in front of a double slit and the resulting interference pattern is observed. If

85

d is the distance from the centre of one slit to the centre of the second slit,

A1

w is the width of each slit,

(A)

L is the distance from the slits to the screen,

-

**

Δx is the distance between adjacent dark lines of the interference pattern,

the wavelength of the light is given by

(A) $\frac{d\Delta x}{L}$

(B) $\frac{Ld}{w}$

(C) $\frac{dw}{L}$

(D) $\frac{\Delta x L}{w}$

(E) $\frac{Ld}{\Delta x}$

12

A student performs a double slit experiment to measure the wavelength of light of a given colour.

S17C

II.6.a

In addition to the average distance between adjacent dark lines and the distance from the slits to the screen, the student must also know

85

C4

A8

(A)

(A) the distance between the two slits.

(B) the location of the central maximum.

(C) the distance of the light source from the double slit.

-

**

(D) the angle measured from the central maximum.

(E) the perpendicular distance from a point on a given nodal line to the centre line.

13

A monochromatic light source and a double slit are used to produce interference fringes on a screen. The screen is 1.50 m from the double slit. The distance between slits is 0.20 mm and the average distance between adjacent dark lines is 0.45 cm.

S17C

II.6.a

85

The wavelength of the light used is

F1

(B)

(A) 6.0×10^{-8} m

(B) 6.0×10^{-7} m

-

(C) 6.0×10^{-6} m

(D) 1.5×10^1 m

(E) 3.4×10^1 m

14S17C
II.6.a

85

F1

(C)

-

In a double slit experiment a monochromatic light source was used to produce interference fringes on a screen. The distance between the slits and the screen was 1.50 m and the separation between slits was 0.20 mm. The distance between adjacent dark bands of the resulting interference pattern was 0.40 cm.

If the screen is moved to a distance of 0.75 m from the slits and the slit separation is decreased to 0.10 mm, the distance between adjacent dark lines would become

- (A) 0.10 cm
- (B) 0.20 cm
- (C) 0.40 cm
- (D) 0.80 cm
- (E) 1.6 cm

15S17C
II.6.a

85

F1

(B)

-

Light from a monochromatic source passes through a double slit with slit separation of 0.20 mm. The distance between adjacent dark bands in the resulting interference pattern is 0.50 cm.

If the slit separation is decreased to 0.10 mm, the distance between adjacent dark bands would become

- (A) 2.0 cm
- (B) 1.0 cm
- (C) 0.50 cm
- (D) 0.25 cm
- (E) 0.10 cm

16S17C
II.6.a

85

F1

(A)

-
**

In a double slit experiment a monochromatic light source is used to produce interference fringes on a screen. The distance between the slits and screen is 1.50 m. The bright fringes are separated by 0.30 cm.

If the screen was moved so that it was 1.0 m from the slits, the average distance between adjacent dark lines would be

(A) 0.20 cm

(B) 0.30 cm

(C) 0.45 cm

(D) 0.67 cm

(E) 1.5 cm

17S17C
II.6.a

85

F1

(C)

-

In a double slit experiment a monochromatic light source with a wavelength of 6.0×10^{-5} cm is used to produce interference fringes on a screen. The screen is placed 150 cm from the double slit. The distance between the slits is 0.10 mm.

The average distance between adjacent dark lines is

(A) 4.0×10^{-9} cm(B) 9.0×10^{-5} cm

(C) 0.90 cm

(D) 1.1 cm

(E) 2.5×10^4 cm

18S17C
II.5.a

Two point sources 4.5 cm apart are vibrating in phase in a ripple tank. The experimenter counts exactly 10 nodal lines in the entire interference pattern.

85

What is the approximate wavelength of the water waves in the tank?

F1

(B)

-

(A) 0.45 cm

(B) 1.0 cm

(C) 1.5 cm

(D) 10 cm

(E) Insufficient data are given to determine a value.

19S17C
II.5.a

Two identical sources of the same frequency, vibrating 8 cm apart in a ripple tank, produce 5 nodal lines on each side of the centre line.

85

What will be observed if the frequency of the sources is doubled?

F1

(C)

-
**

(A) The average distance of the nodal lines from the centre line increases.

(B) The speed of propagation of the water waves increases.

(C) The number of nodal lines on each side of the centre line doubles.

(D) The wavelength of the water waves doubles.

(E) The kinetic energy of the water waves decreases.

20S17C
II.6.a

In an experiment to measure wavelength using a double slit, it is found that the interference fringes are so close together that they are difficult to count.

S 85

In order to increase the distance between the fringes, one could

F1

(A)

(A) either halve the slit separation, or double the distance from the source.

-

(B) either double the slit separation, or double the distance from the source.

(C) halve both the slit separation and the distance from the source.

(D) either double the slit separation, or halve the distance from the source.

(E) halve the size of the source and double the frequency of the source.

21S17C
II.6.a

The interference pattern of monochromatic light is to be used to measure very small distances. Numerous clearly defined interference lines, as widely spaced as possible, are required.

S 85

Which of the following experiment conditions will produce the most suitable interference pattern?

F1

(E)

(A) Green light incident on a wide single slit.

(B) Red light incident on a narrow single slit.

-

(C) Blue light incident on a double slit which has a narrow slit width and a large distance between the slits.

(D) Red light incident on a double slit which has a wide slit width and a small distance between the slits.

(E) Red light incident on a double slit which has a narrow slit width and a small distance between the slits.

22

Light from a monochromatic source shines on a single slit.

S17C

II.6.b

Which diagram best illustrates the interference pattern observed on the screen?

87

B1

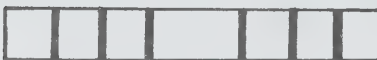
A1

(A)



(B)

(B)



-

(C)



(D)



(E)



23

A student wishes to produce a single slit diffraction pattern in a ripple tank experiment.

S17C

II.6.b

Which two of the following should be decreased to produce more bending?

87

I. the frequency

A10

II. the wavelength

(B)

III. the depth of water

-

IV. the width of slit

(A) I and III

(B) I and IV

(C) II and III

(D) II and IV

(E) III and IV

24

Light passing through a single slit produces a diffraction pattern on a screen. Consider the following statements with respect to this pattern:

S17C

II.6.b

I. If light of a longer wavelength is used, the central maximum will be broader.

87

F1

II. If white light is used, the edges of the central maximum will be coloured.

(E)

III. If a narrower slit is used, the central maximum will be broader.

-

Which of the above statements is/are correct?

(A) II only

(B) I and II only

(C) I and III only

(D) II and III only

(E) I, II and III

25

S17C

II.6.b

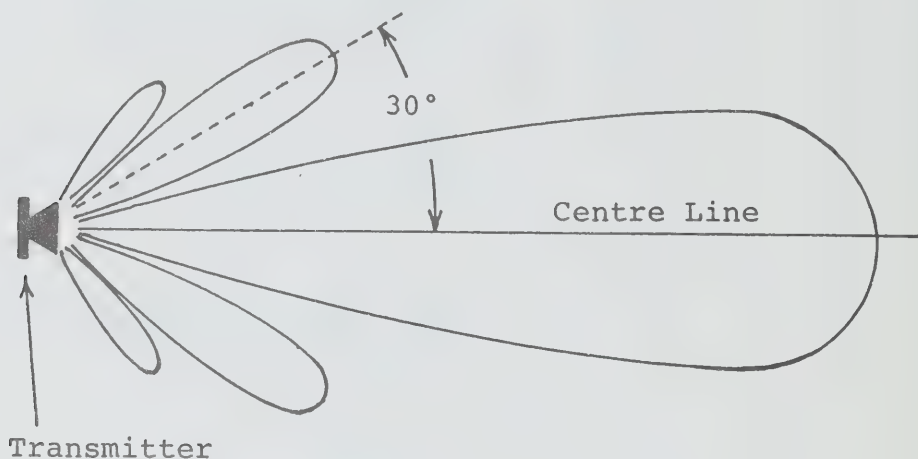
S 87

F1

(C)

-

A sonar transmitter, producing 14 kHz sound waves in water, causes the intensity pattern below. The dark lines represent positions where the intensity of the sound is constant. The speed of sound in the water is 1400 m/s. The intensity pattern is analogous to the effect of single slit interference of light.



The width of the vibrating surface of the transmitter is approximately

- (A) 0.10 m
- (B) 0.20 m
- (C) 0.30 m
- (D) 0.90 m
- (E) The width cannot be determined from the available data.

26

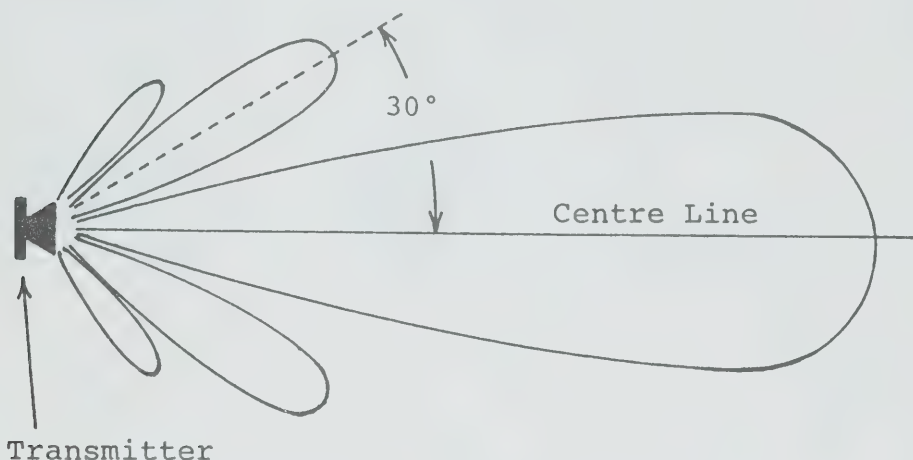
S17C
II.6.b

S 87

F1

(B)

A sonar transmitter, producing 14 kHz sound waves in water, causes the intensity pattern below. The dark lines represent positions where the intensity of the sound is constant. The speed of sound in the water is 1400 m/s. The intensity pattern is analogous to the effect of single slit interference of light.



A sonar device is most effective when the width of the central maximum is very small. Which of the following combinations will produce the narrowest central maximum?

- (A) Keep the frequency constant and halve the size of the vibrating surface.
- (B) Double the frequency and double the size of the vibrating surface.
- (C) Halve the frequency and double the size of the vibrating surface.
- (D) Double the frequency and halve the size of the vibrating surface.
- (E) Halve the frequency and halve the size of the vibrating surface.

27

Which of the following properties can be explained by the wave theory of light, but not by the particle theory of light?

S17C

II.6.e

S 88

S 68

A1

(D)

-

**

(A) Light travels in a straight line.

(B) Light is reflected from a shiny surface.

(C) Light emits electrons from a negative zinc plate.

(D) Light is diffracted around the edge of an obstacle.

(E) Light absorbed by a black surface is transformed into heat.

28

S17C

II.6.c

S 88

F1

A3

(C)

-

Light from a monochromatic source is shone toward two thin films as shown in the diagram. The arrows indicate different paths light might take. The thicknesses of the films are given in terms of the wavelength of the light in each film. Positions I, II, III and IV are places a photometer can be placed to take readings.

The photometer would read maximum readings at positions

(A) I and III

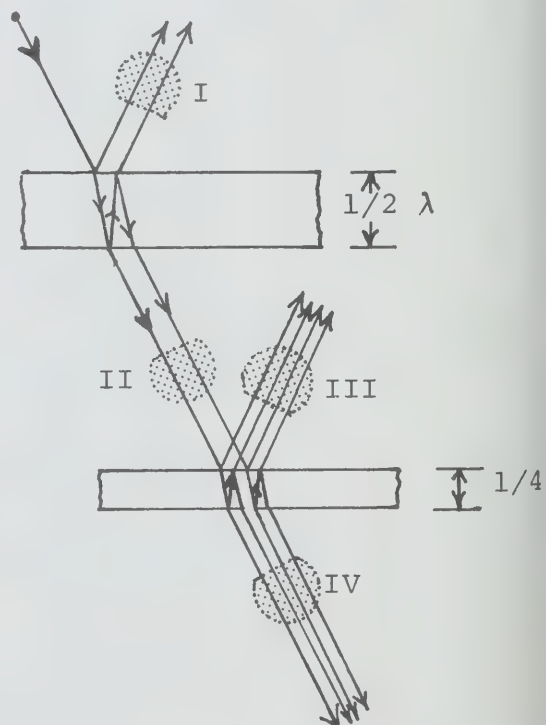
(B) I and IV

(C) II and III

(D) II and IV

(E) I and II

Monochromatic
Light



29

Three experiments for studying the interaction of monochromatic light with thin films of glass of various thicknesses t are shown. The eye shows the position of the observer.

S17C

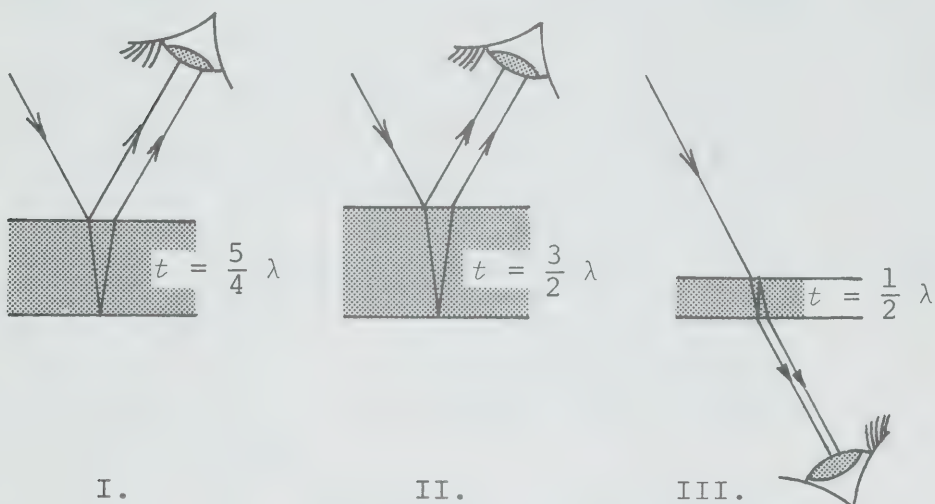
II.6.c

S 88

F1

A8

(D)

-
***

Which experiment(s) will produce constructive interference as seen by the observer?

- (A) I only
- (B) II only
- (C) III only
- (D) I and III only
- (E) II and III only

30S17C
II.6.c

S 88

F1
A11
A3

(C)

-

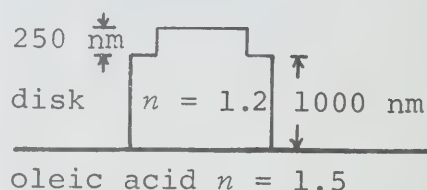
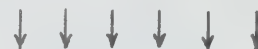
A thin, transparent disk has a refractive index n of 1.2. The diagrams show the shape of the disk as seen from above and from the side.

Top View



Side View

Monochromatic Light



What would the interference pattern due to the disk look like if viewed from a position above the disk and then from a position below the disk?

View	(A)	(B)	(C)	(D)	(E)
As seen from above					
As seen from below					

31

Light is sometimes described as a wave motion because

S17C
II.6.e

(A) Einstein, a prominent scientist, said that light is a wave motion.

SS 88

(B) light waves have been observed directly by scientists.

A9

(C) light behaves at all times as a wave.

(D)

(D) many of the properties of light can be explained using a wave model.

-
*

(E) all of the properties of light can be explained using a wave model.

32

Monochromatic light strikes a thin film normal to the surface.

S17C
II.6.c

The thickness of the film needed to obtain the first bright reflected maximum, in terms of the wavelength of the light in the film, is

SS 88

F1 (A) very thin compared to λ

(B)

(B) $\frac{1}{4} \lambda$

-

(C) $\frac{1}{2} \lambda$

(D) $\frac{3}{4} \lambda$

(E) λ

33S17C
II.6.c

A lens is coated with a thin transparent film in order to reduce reflection of the red component of white light. The index of refraction of the film is 1.3 and that of the lens is 1.6.

SS 88

The minimum thickness of the film, in terms of the wavelength of red light in the film, is

F1

(B)

-
***(A) less than $\lambda/4$ (B) $\lambda/4$ (C) $\lambda/2$ (D) λ (E) greater than λ **34**S17C
II.6.c

A thin coating is applied to a glass camera lens to minimize the intensity of the light reflected from the lens. The coating has an index of refraction of 1.2. The wavelength of the light in air is λ .

SS 88

F1

What is the smallest thickness of the coating, in terms of λ , needed to minimize the intensity of the reflected light?

(D)

-
***(A) $\frac{\lambda}{2}$ (B) $\frac{\lambda}{2 \times 1.2}$ (C) $\frac{1.2 \lambda}{4}$ (D) $\frac{\lambda}{4 \times 1.2}$ (E) $\frac{\lambda}{4}$

1

The wave model of light predicts that light slows down when it travels from air into glass.

S17C

II.4.c

(A) True

82

(B) False

E3

A1

(A)

-

**

2

The diagram below shows measurements that can be made on the interference pattern formed with two point sources of light S_1 and S_2 . Point P lies on the first nodal line.

S17C

II.6.a

85

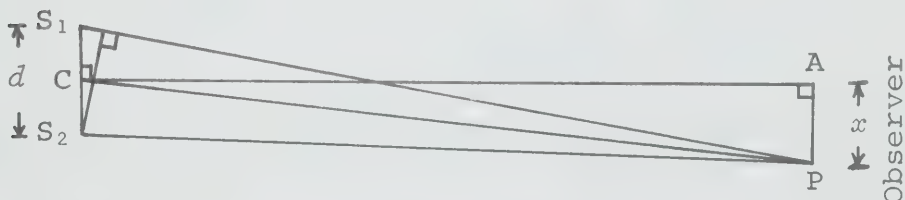
A3

A8

(B)

-

**



If d is constant and the frequency increases, the distance x increases.

(A) True

(B) False

3

Light behaves at all times as a wave.

S17C

II.6.e

(A) True

(B) False

SS 88

A9

(B)

-

*

4

S17C
II.6.a

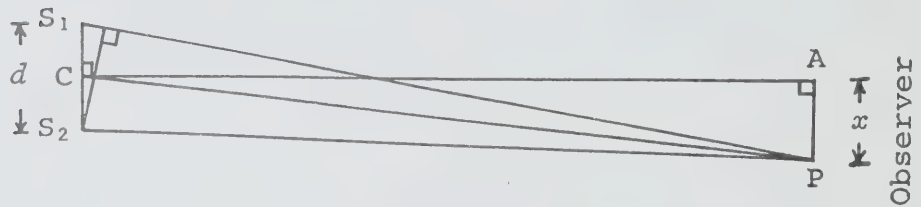
The diagram below shows measurements that can be made on the interference pattern formed with two point sources of light S_1 and S_2 . Point P lies on the first nodal line.

85

A3

A8

(B)

-
**

If d is increased, and the wavelength of the light is not changed, the distance x increases.

(A) True

(B) False

5

S17C
II.6.e

Many of the properties of light can be explained using a wave model.

(A) True

SS 88

(B) False

A9

(A)

-
*

6

S17C
II.6.e

All of the properties of light can be explained using a wave model.

(A) True

SS 88

(B) False

A9

(B)

-
*

E L E C T R I C I T Y

A N D

M A G N E T I S M

ELECTRIC FORCES AND CHARGES

1

The electric field caused by six point charges of equal magnitude is shown below.

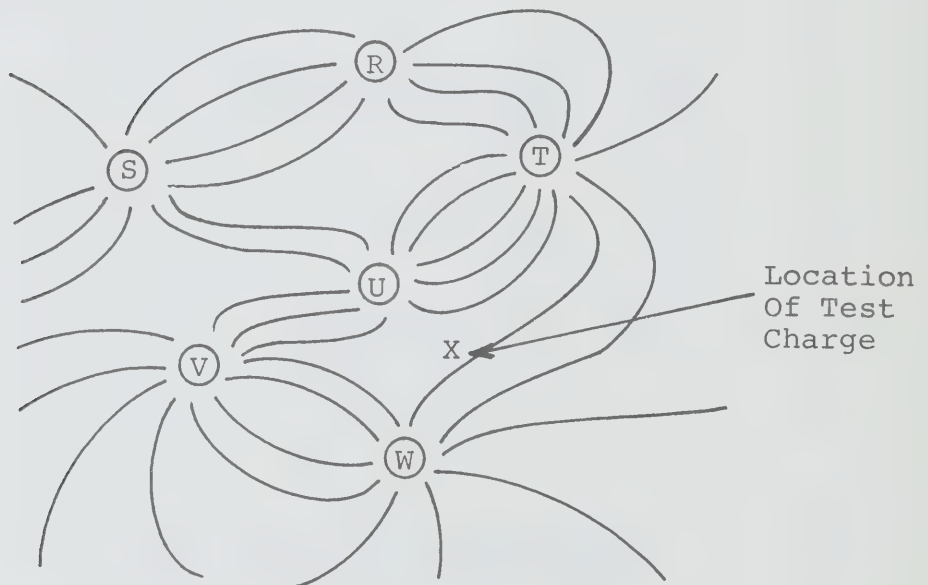
S17C

IV.3.a

S 89

F1

(E)

-
***

If R is a positive charge, then the vector sum of the forces acting on a negative test charge located at point X has

- (A) a direction 
- (B) a direction 
- (C) no net force or direction
- (D) a direction 
- (E) a direction 

2S17C
IV.1.a

If Q_1 and Q_2 represent point charges, F the force of electrical attraction or repulsion, and d the distance between point charges, the equation for finding k , the constant in Coulomb's Law is

90

(A) $k = \frac{Fd}{Q_1 Q_2}$

A8

(B)

(B) $k = \frac{Fd^2}{Q_1 Q_2}$

-
**

(C) $k = \frac{F\sqrt{d}}{Q_1 Q_2}$

(D) $k = \frac{FQ_1 Q_2}{d^2}$

(E) $k = \frac{FQ_1 Q_2}{d}$

3S17C
IV.1.a

Two metal spheres, one having a charge of 4.0×10^{-6} C and the other having a charge of 2.0×10^{-6} C, are 3.0 cm apart.

90

If $k = 9.0 \times 10^9$ N·m²/C², what is the electrical force between them?

A8

(A) 8.0×10^1 N

F1

(B) 2.4 N

(A)

(C) 8.0×10^{-1} N

-

(D) 8.0×10^{-3} N

(E) 6.5×10^{-5} N

4

S17C
IV.1.a

90

A8

F1

(E)

-

Two point charges attract each other with a force of F when they are a distance d apart. The charge on each sphere is reduced to one-quarter of its original value and the distance is increased by one-half of the original distance between them.

What is the new force between them?

(A) $\frac{1}{4} F$

(B) $\frac{9}{64} F$

(C) $\frac{3}{32} F$

(D) $\frac{1}{24} F$

(E) $\frac{1}{36} F$

5

S17C
IV.1.b

90

A8

F1

(D)

-

**

Three small spheres x , y , and z , having charges as indicated on the diagram, are the same distance apart. Spheres y and z are held in place, and sphere x is free to move on a frictionless surface.

Which path will sphere x take when released?

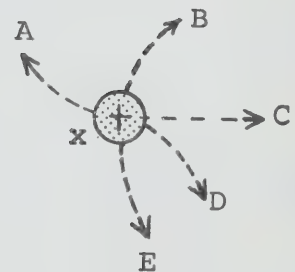
(A) A

(B) B

(C) C

(D) D

(E) E



6

S17C
IV.2.a

90

35

20

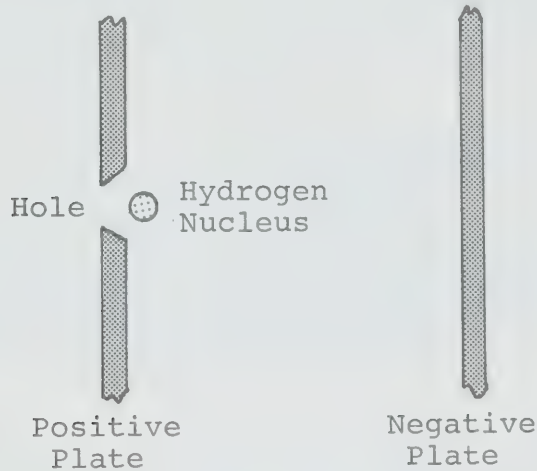
F1

A8

(E)

—

A hydrogen nucleus enters the field between two oppositely charged metal plates through a hole in the positive plate. The hydrogen nucleus accelerates from rest and arrives at the negative plate with a speed v .



A helium nucleus with four times the mass and twice the charge of the hydrogen nucleus enters the field through the hole at negligible speed.

If the helium nucleus accelerates from rest, what will be its speed at the negative plate?

- (A) $v/2$
- (B) $\sqrt{2} v$
- (C) $v\sqrt{2}$
- (D) $2\sqrt{v}$
- (E) $v/\sqrt{2}$

7

Two identical positive charges, x and y , and a positive test charge, z , are located at the vertices of a triangle as shown.

S17C

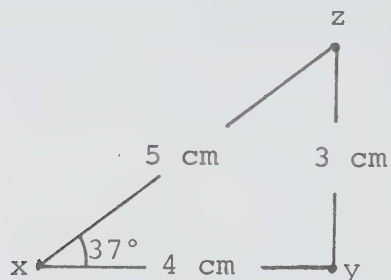
IV.1.b

90

F1

(A)

-

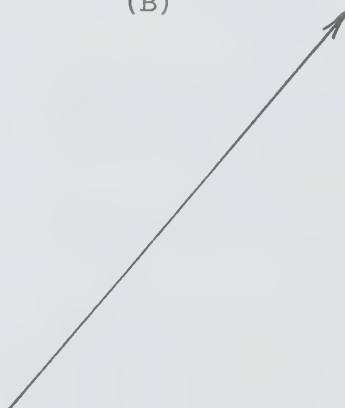


Which diagram best illustrates the net force acting on test charge z due to charges x and y ? The force vectors are all drawn to the same scale.

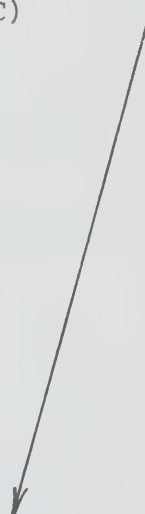
(A)



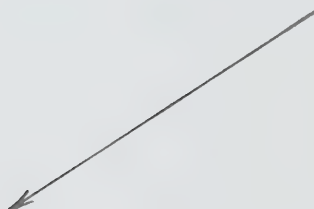
(B)



(C)



(D)



(E)



8

S17C

IV.1.d

90

40

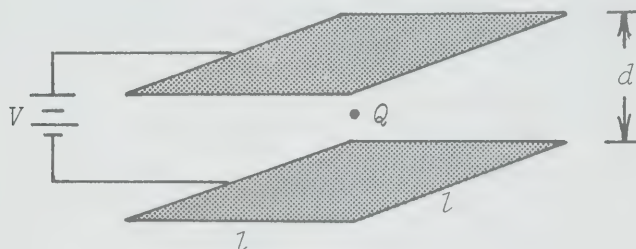
F1

A8

(D)

-

A small sphere carries a charge Q . The sphere is placed between two square metal plates having linear dimensions of l . The plates are separated by a distance d and attached to a battery with an electric potential V . When the battery is disconnected and there is no charge on the plates, the sphere falls with a speed v . When the battery is connected as shown, the sphere rises with a speed $\frac{1}{2} v$.



When the battery is connected, the ratio of the electric force to the gravitational force on the sphere is

- (A) 1:2
- (B) 2:3
- (C) 1:1
- (D) 3:2
- (E) 2:1

9

S17C
IV.1.a

91

A8

A5

A11

Identical negative charges X and Y, with identical velocities, are approaching a fixed positive charge Z in the direction shown. The force between charge Z and each of the moving charges X and Y is inversely proportional to the square of the separation. Ignore the interaction between charges X and Y.



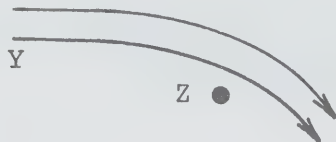
Z ●

(C)

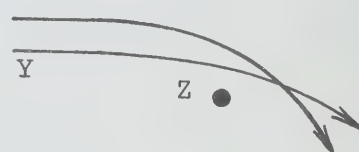
The paths followed by charges X and Y are best illustrated by

**

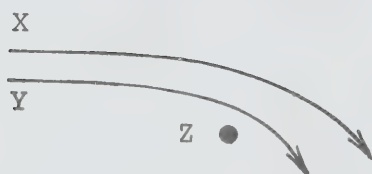
(A) X



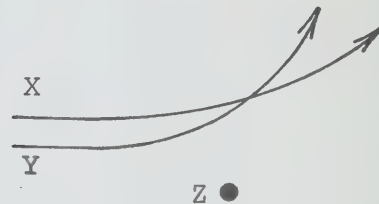
(B) X



(C)



(D)



(E)



10

Two identical charged spheres repel each other with a force F when their centres are a distance d apart.

S17C

IV.1.a

91

F1

If the charge on one sphere is doubled, the charge on the other sphere is tripled, and the separation is increased to $4d$, what will be the force of repulsion?

(B)

(A) $\frac{5}{16} F$

-

(B) $\frac{3}{8} F$

(C) F

(D) $\frac{5}{4} F$

(E) $\frac{6}{4} F$

11

Two small spheres, X and Y, are arranged as shown in the following diagram. The sign and magnitude of the charge on each sphere is shown. (Coulomb's constant $k = 9.0 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}$)

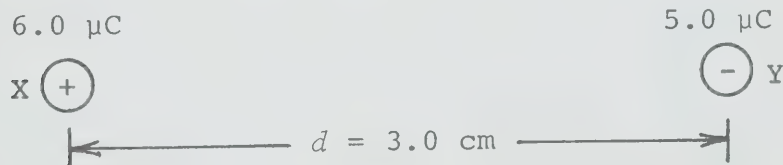
S17C

IV.1.b

91

F1

(B)

-

What is the size and nature of the electrical force between the two charged spheres?

(A) 300 N (repulsion)

(B) 300 N (attraction)

(C) 600 N (attraction)

(D) 900 N (repulsion)

(E) 900 N (attraction)

12

Four charged spheres W, X, Y and Z are arranged as illustrated in the following diagram. The sign and magnitude of each charge is shown.

S17C

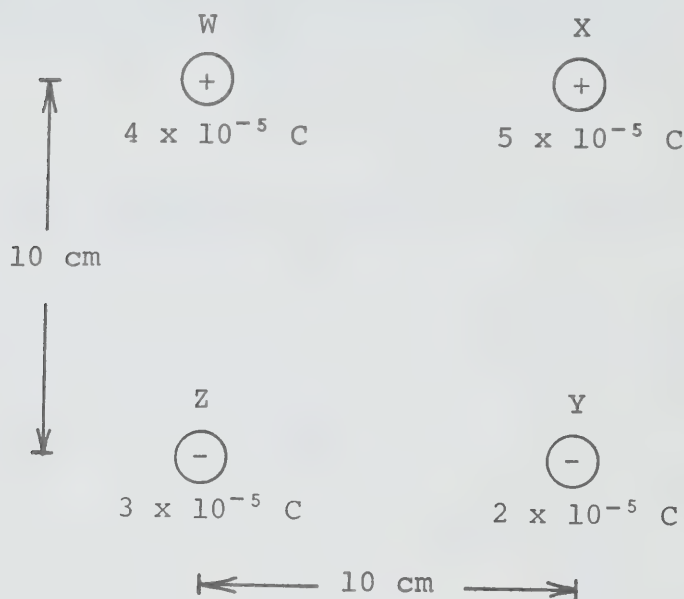
IV.1.a

91

F1

(A)

-



The ratio of the magnitude of the force exerted by X on Z to that exerted by W on Y is

- (A) 15:8
- (B) 6:8
- (C) 8:15
- (D) 1:1
- (E) 4:3

13

S17C
IV.1.a

91

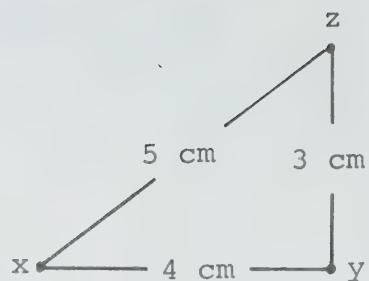
F1

(B)

-

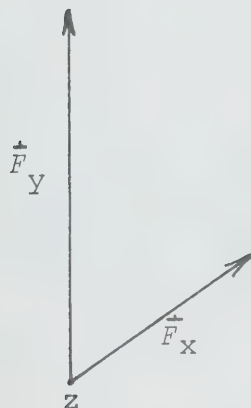
Two identical positive charges, x and y, and a positive test charge, z, are located at the vertices of a triangle.

The distances between the charges are shown.

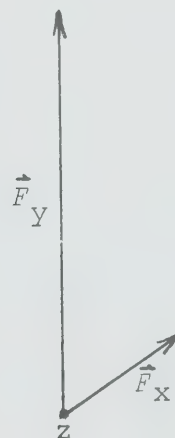


Which diagram best illustrates the force due to x ($\vec{F}_x$), and the force due to y ($\vec{F}_y$) acting on the test charge z? The force vectors are all drawn to the same scale.

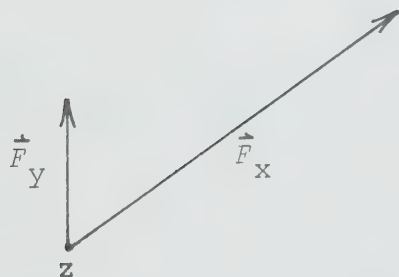
(A)



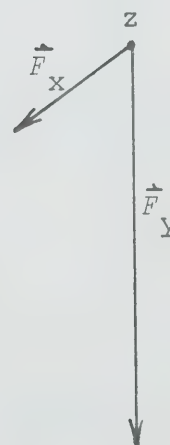
(B)



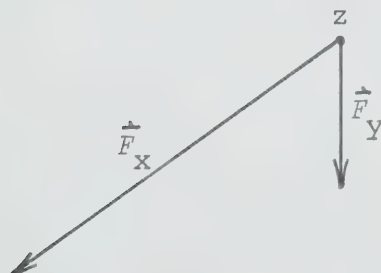
(C)



(D)



(E)



14

Four charged spheres W, X, Y and Z are arranged as illustrated in the following diagram. The sign and magnitude of each charge is shown.

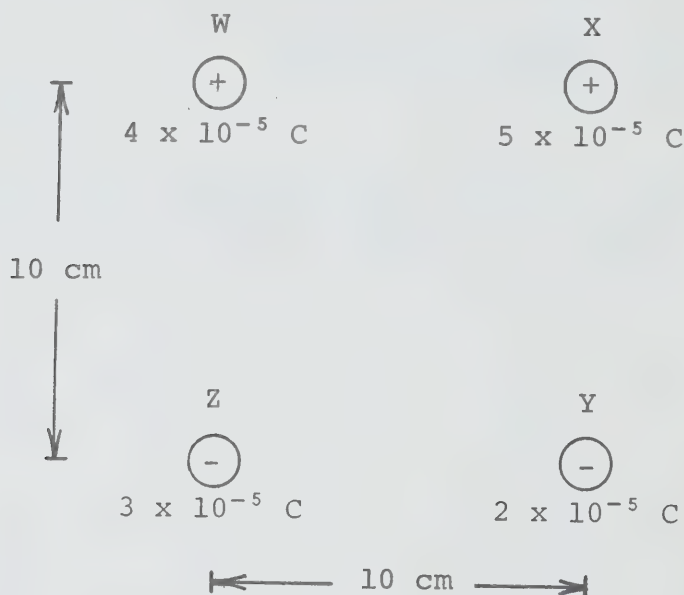
S17C

IV.1.a

91

F1

(A)

-
***

The ratio of the magnitude of the electric force exerted by W on X to that exerted by Y on Z is

- (A) 10:3
- (B) 9:5
- (C) 1:1
- (D) 5:9
- (E) 3:10

15

Two similar charges Q_1 and Q_2 exert a force of 24 N on each other when they are 10 cm apart.

S17C

IV.1.1.a

If the charges remain the same and the distance is reduced to 5.0 cm, the force exerted will be

91

(A) 6.0 N

F1

(B) 12 N

(E)

(C) 36 N

-

(D) 48 N

(E) 96 N

16

Three identical small metal spheres, X, Y and Z, with equal electrical charges are spaced 10 cm apart along a straight line as shown. The magnitude of the net electric force on sphere X is F .

S17C

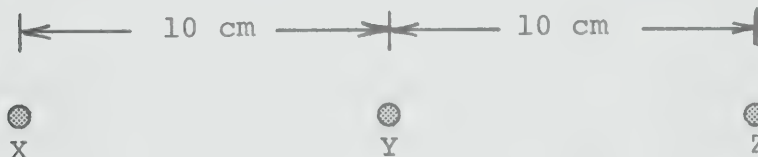
IV.1.1.b

91

F1

(A)

-



If sphere Z is moved next to sphere Y so that both spheres are 10 cm from sphere X, the magnitude of the net electric force on sphere X is closest to

(A) $\frac{8}{5} F$ (B) $8 F$ (C) $\frac{5}{4} F$ (D) $\frac{25}{16} F$ (E) $\frac{20}{15} F$

17

S17C

IV.1.a

III.3.b

91

40

F1

A8

(E)

In the Rutherford model of the hydrogen atom, the proton is the nucleus, and there is one electron moving around it in orbit. M is the mass of the proton, m the mass of the electron, Q the charge on the proton, q the charge on the electron, r the radius of orbit, G the universal gravitation constant, and k Coulomb's force constant.

If F_e is the electrostatic force of attraction between the proton and electron, and F_g is the gravitational force of attraction, what is the ratio F_e/F_g ?

-
**

(A) $\frac{kQq}{GMmr^2}$

(B) $\frac{GQq}{kMm}$

(C) $\frac{kMm}{GQq}$

(D) $\frac{GMm}{kQq}$

(E) $\frac{kQq}{GMm}$

18

A charge R is placed to the right of charge S.
The sign and magnitude of each charge is shown.

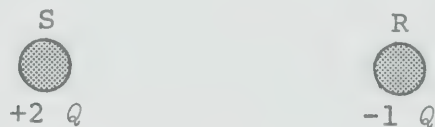
S17C

IV.1.b

S 91

F1

(C)

-
***

Where must a charge T of magnitude $+1 Q$ be placed,
if the net electrical force on T is to be zero?

- (A) only to the left of S along a line passing through S and R
- (B) either to the left of S, or between S and R, on a line passing through S and R
- (C) only to the right of R along a line passing through S and R
- (D) somewhere between S and R, but not on the line passing through S and R
- (E) Charge T cannot be placed anywhere to meet the conditions described since charges S and R have different magnitudes.

19

Points R and T are an equal distance d from two equal and opposite charges as shown.

S17C

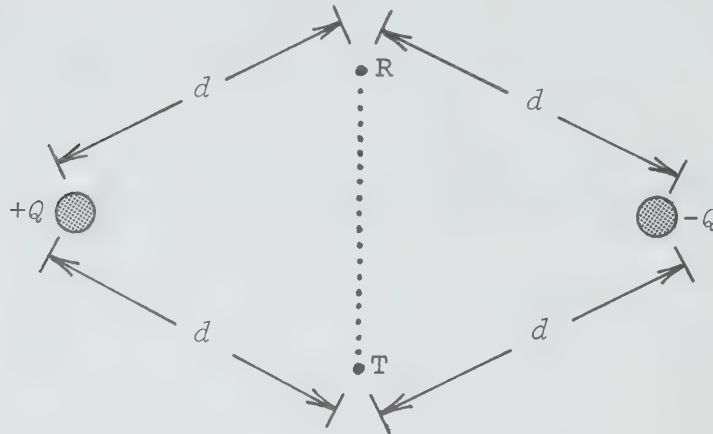
IV.1.b

S 91

S 47

F1

(A)

-
***

The amount of work to move a unit negative test charge from point R to point T is

(A) zero

(B) $\frac{kQ^2}{d^2}$ (C) $\frac{kQ^2}{d}$ (D) $\frac{kQ^2}{\sqrt{2} d}$ (E) $\frac{kQ^2}{2 d}$

20

Points R and T are an equal distance d from two equal and opposite charges as shown.

S17C

IV.1.b

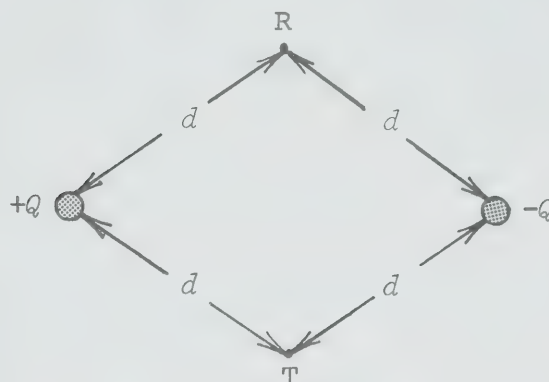
S 91

S 47

F1

(A)

-



The amount of work to move a unit positive charge from point R to point T is

(A) zero

(B) $\frac{kQ^2}{d^2}$ (C) $\frac{kQ^2}{d}$ (D) $\frac{kQ^2}{\sqrt{2}d}$ (E) $\frac{kQ^2}{2d}$

21

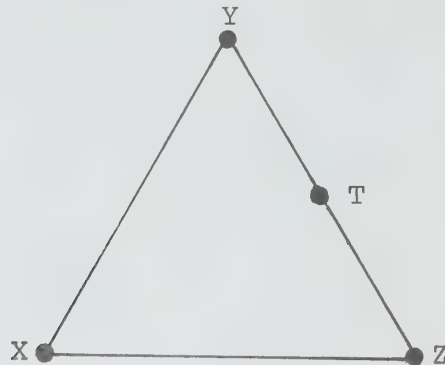
S17C
IV.1.a

Three identical unit charges, X, Y and Z, are placed so that they form the vertices of an equilateral triangle. Each charge exerts a force F on the other two charges.

92

F1

(D)

-
***

If an identical unit test charge T is placed midway between Y and Z as shown, what is the net electrical force exerted on T by charges X, Y and Z?

(A) F

(B) $\frac{1}{2} F$

(C) $\frac{\sqrt{3}}{2} F$

(D) $\frac{4}{3} F$

(E) $2 F$

22

S17C
IV.1.b

92

F1
A3

(E)

-

The accompanying diagram represents charged spheres X, Y and Z. Sphere X and sphere Y have identical charges. Sphere Z has a charge equal in magnitude and opposite in sign to that of sphere X. The spheres are placed in a straight line so that the distance from X to Y equals the distance from Y to Z.



If the electric force of sphere X on sphere Y is 4.0 N, what is the magnitude of the net electric force exerted on sphere Y?

- (A) zero
- (B) 2.0 N
- (C) 4.0 N
- (D) 5.0 N
- (E) 8.0 N

ELECTRIC FIELD

AND POTENTIAL

1

Consider the following statements concerning an electric force field:

S17C

IV.1.c

93

A2

(E)

-

I. It is usually defined as the electric force per unit of positive charge.

II. The size of the electric force on a charge in a force field is directly proportional to the size of the force field at the location of the charge.

III. The direction of the force field at the point is the direction in which a free positive charge would accelerate.

Which of the above statements is/are correct?

- (A) I only
- (B) II only
- (C) I and II only
- (D) II and III only
- (E) I, II and III

2

The electric field of a positive point charge may be correctly represented by

- S17C
IV.1.c
- (A) equally spaced clockwise concentric circles.
- 93
- (B) equally spaced counterclockwise concentric circles.
- A4
- (C) equally spaced parallel lines.
- (D)
- (D) symmetrical lines radiating away from the point charge.
-
- ***
- (E) symmetrical lines radiating toward the point charge.

3

If the separation r between a positive test charge and a positive point charge is decreased by an experimenter, the force F on the test charge will

- S17C
IV.3.a
- (A) decrease according to $F \propto r$.
- 94
- (B) increase according to $F \propto 1/r$.
- F1
- (C) remain constant.
- (E)
- (D) decrease according to $F \propto r^2$.
-
- **
- (E) increase according to $F \propto 1/r^2$.

4

S17C
IV.1.b

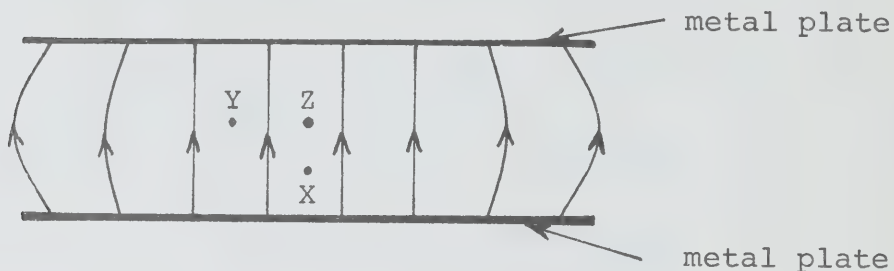
95

A11
A4

(B)

-

The diagram below shows the electric field (fine lines) created by a pair of uniformly charged parallel metal plates (heavy lines).



Which one of the following statements can be deduced correctly from the diagram?

- (A) The top plate is positive and the bottom plate is negative.
- (B) A positively charged small sphere at X would experience the same electric force as it would if it were placed at Y.
- (C) A positively charged small sphere at X would experience greater electric force than if it were at Z.
- (D) A positively charged small sphere at X would experience less electric force than if it were at Z.
- (E) A negatively charged object located between the plates could have the gravitational force on it balanced by the electric force caused by the plates.

5

S17C
IV.1.d

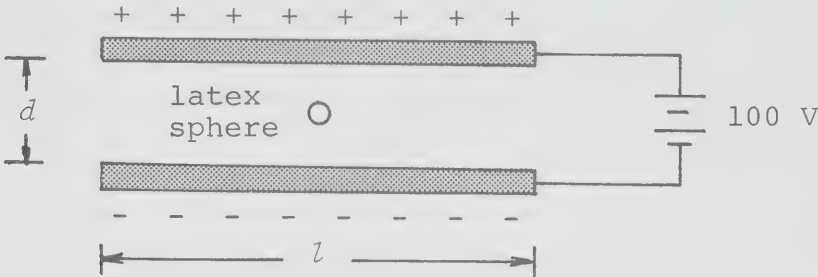
SS 98

F1

(E)

-

A small latex sphere of mass m and negative charge $-Q$ is placed between the two charged plates of a Millikan apparatus. The plates have a length l and are a distance d apart. When a potential difference V of 100 V is produced by connecting a battery between the plates so that the upper plate is positive and the bottom plate is negative, the charged sphere is held in balance as shown.



Which of the following conditions of mass, charge, potential difference, plate length, and plate separation would also hold the sphere in balance?

	Mass	Charge	Potential Difference	Plate Length	Plate Separation
(A)	m	$-Q$	100 V	$2 l$	$d/2$
(B)	$2 m$	$-Q$	200 V	l	$2 d$
(C)	m	$-2 Q$	200 V	l	d
(D)	$2 m$	$-\frac{1}{2} Q$	200 V	l	d
(E)	$2 m$	$-2 Q$	50 V	l	$d/2$

6

The conclusion from the Millikan oil drop experiment was that

S17A

IV.2.b

S17C

IV.1.d

98

A3

A9

(E)

(A) the mass to charge ratio of the electrons is very small.

(B) the speed of the electrons is very great.

(C) the electron has a negative charge.

(D) the proton has a positive charge.

(E) there exists a smallest electric charge.

-

7

Which graph best represents the speed of a charged particle in a uniform electric field as a function of time?

S17C

IV.3.a

99

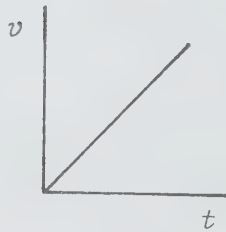
A11

A3

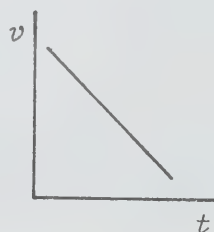
(A)

-

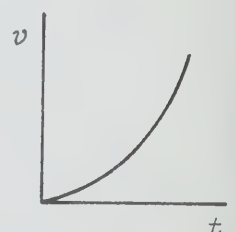
(A)



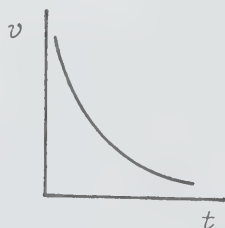
(B)



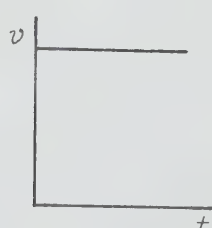
(C)



(D)



(E)



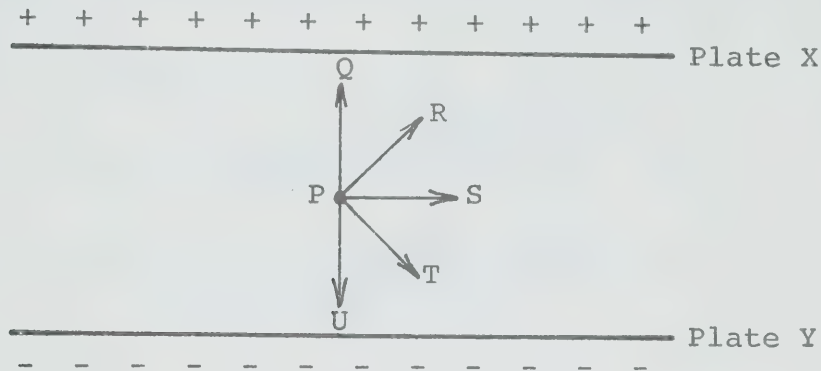
8

S17C
IV.1.c99
93F1
A8

(D)

-

A small sample of a radioactive isotope is located at point P. The isotope is in a uniform electric field produced by two oppositely charged plates X and Y in a vacuum. The isotope is emitting beta particles (electrons). Five directions are shown.



The acceleration of these beta particles due to the electric field is

- (A) greatest for those emitted in the direction Q.
- (B) least for those emitted in the direction S.
- (C) zero.
- (D) the same in all directions.
- (E) greatest for those emitted in the direction R.

9

S17A
IV.2.c

With the use of a cloud chamber, a student observes particles emitted from a radioactive source. The student observes that the tracks are straight lines and hypothesizes that the particles causing them are uncharged.

99

C3

A suitable method for testing this hypothesis is to repeat the observations

(B)

(A) using a larger cloud chamber to allow longer path lengths.

**

(B) after placing the cloud chamber in a magnetic field.

(C) after increasing the pressure in the chamber.

(D) after decreasing the pressure in the chamber.

(E) using a different substance for the vapour.

10

S17C
IV.1.d

Two oppositely charged parallel metal plates are connected to a battery of electrical potential V .

Which graph best represents the electric field E between the two plates as a function of their area A ?

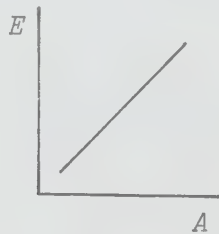
A11

A1

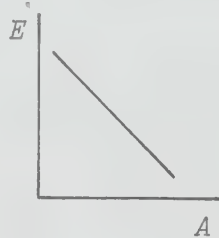
(E)

-

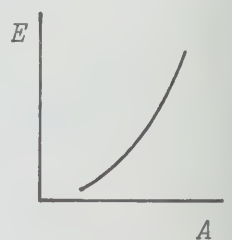
(A)



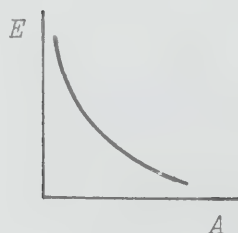
(B)



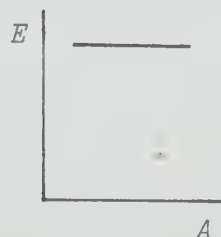
(C)



(D)



(E)



11

S17C

IV.1.d

S 99

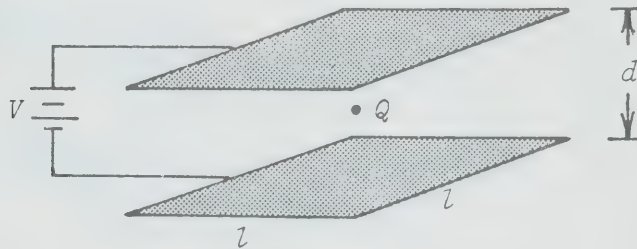
F1

A5

(D)

-

A small sphere carries a charge Q . The sphere is placed between two square metal plates having linear dimensions of l . The plates are separated by a distance d and attached to a battery with an electric potential V . When the battery is disconnected and there is no charge on the plates, the sphere falls with a speed v . When the battery is connected as shown, the sphere rises with a speed $\frac{1}{2} v$.



If the charge is tripled, the separation between the plates is doubled, and the plates are connected to the battery, the sphere will

- (A) move downward.
- (B) stand still.
- (C) move upward at $3 v$.
- (D) move upward at $\frac{5}{4} v$.
- (E) move upward at $2 v$.

12

S17C
IV.1.d

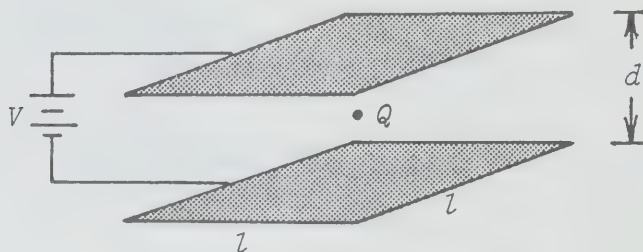
S 99

F1
A3
A8

(E)

-

A small sphere carries a charge Q . The sphere is placed between two square metal plates having linear dimensions of l . The plates are separated by a distance d and attached to a battery with an electric potential V . When the battery is disconnected and there is no charge on the plates, the sphere falls with a speed v . When the battery is connected as shown, the sphere rises with a speed $\frac{1}{2} v$.



If the charge on the sphere is doubled, the sphere will

- (A) move downward at $2 v$.
- (B) stand still.
- (C) move upward at v .
- (D) move upward at $\frac{3}{2} v$.
- (E) move upward at $2 v$.

13

S17C

IV.1.d

S 99

F1

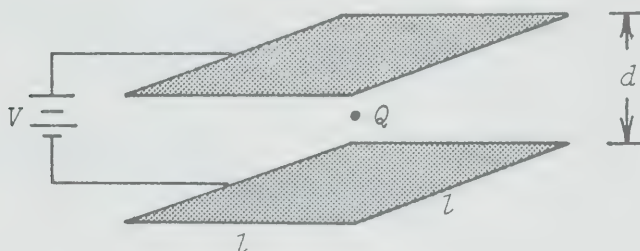
A3

A8

(D)

-

A small sphere carries a charge Q . The sphere is placed between two square metal plates having linear dimensions of l . The plates are separated by a distance d and attached to a battery with an electric potential V . When the battery is disconnected and there is no charge on the plates, the sphere falls with a speed v . When the battery is connected as shown, the sphere rises with a speed $\frac{1}{2} v$.



If both linear dimensions of the plates are doubled, without disconnecting the battery or changing the separation, the sphere will

- (A) move downward at $\frac{1}{2} v$.
- (B) stand still.
- (C) move upward at $\frac{1}{2} v$.
- (D) move upward at $\frac{1}{2} v$.
- (E) move upward at v .

14

S17C

IV.1.d

S 99

F1

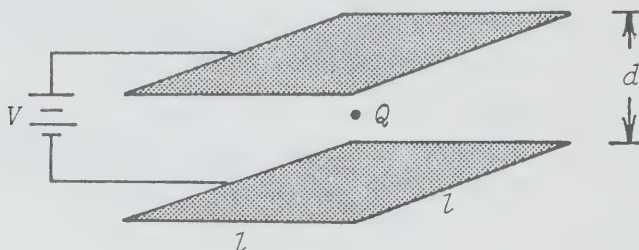
A3

A8

(A)

-

A small sphere carries a charge Q . The sphere is placed between two square metal plates having linear dimensions of l . The plates are separated by a distance d and attached to a battery with an electric potential V . When the battery is disconnected and there is no charge on the plates, the sphere falls with a speed v . When the battery is connected as shown, the sphere rises with a speed $\frac{1}{2} v$.



If the separation between the plates is doubled and the same battery is connected, the sphere will

- (A) move downward at $\frac{1}{4} v$.
- (B) move downward at $\frac{1}{2} v$.
- (C) stand still.
- (D) move upward at $\frac{1}{4} v$.
- (E) move upward at $\frac{1}{2} v$.

15

S17C
IV.1.d

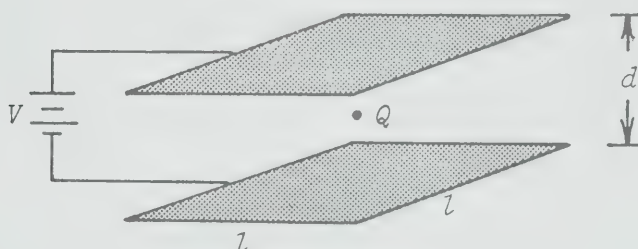
S 99

F1
A3
A8

(C)

-

A small sphere carries a charge Q . The sphere is placed between two square metal plates having linear dimensions of l . The plates are separated by a distance d and attached to a battery with an electric potential V . When the battery is disconnected and there is no charge on the plates, the sphere falls with a speed v . When the battery is connected as shown, the sphere rises with a speed $\frac{1}{2} v$.



If the electric potential of the battery is doubled without changing the separation between the plates, the sphere will move upward with a speed of

- (A) v
- (B) $\frac{3}{2} v$
- (C) $2 v$
- (D) $\frac{5}{2} v$
- (E) $3 v$

CURRENT ELECTRICITY

AND ELECTROMAGNETISM

1 Which one of the following meters can be used to read directly the current flowing from a photoelectric cell when light is incident on it?

S17C
IV.6.c

101

B4

(A)

-
**

(A) microammeter

(B) photometer

(C) ohmmeter

(D) micrometer

(E) wattmeter

2 Which one of the following meters can be used to read directly the current flowing from a photoelectric cell when light is incident on it?

S17C
IV.6.c

101

B4

(C)

-
**

(A) voltmeter

(B) ohmmeter

(C) microammeter

(D) light meter

(E) wattmeter

3

The order of magnitude which comes closest to the number of kilowatt hours of energy consumed by an average household in a month is

S17A
III.2.h

S 106

F1

(D)

-
**

(A) 10^{-2}

(B) 10^{-1}

(C) 10^0

(D) 10^3

(E) 10^5

4

The order of magnitude which comes closest to the number of megajoules of energy consumed by an average household in a month is

S17A
III.2.h

S 106

F1

(D)

-

(A) 10^{-2}

(B) 10^{-1}

(C) 10^0

(D) 10^3

(E) 10^6

ELECTROMAGNETIC SPECTRUM

1

S17C
IV.4.a

The following types of electromagnetic radiation are listed from (A) to (E) in order of decreasing wavelength, with one out of place. Which one is out of place?

- 110 (A) infrared radiation
- A5 (B) green light
- (E) (C) X rays
- (D) gamma rays
- *** (E) radio waves

2

S17C
IV.4.b

Ultraviolet light is not effective in

S 110

A1

(B)

-

- (A) killing germs in the air.
- (B) penetrating glass.
- (C) producing fluorescence.
- (D) sterilizing air.
- (E) tanning the skin.

3 Electromagnetic radiation is generated by

- S17C
IV.4.b
111
A1
(C)
- (A) electrons moving at constant velocity.
 - (B) accelerating neutral atoms.
 - (C) accelerating charges.
 - (D) electrons in stable atomic orbits.
 - (E) accelerating neutrons.

-
**

4 In a vacuum, the speed of electromagnetic radiation

- S17C
IV.4.b
111
A1
(E)
- (A) increases with frequency.
 - (B) decreases with frequency.
 - (C) increases with photon energy.
 - (D) decreases with photon energy.
 - (E) is the same for all wavelengths.

-
**

5 Which of the following is not a characteristic of electromagnetic waves?

- S17C
IV.4.b
111
A1
(B)
- Electromagnetic waves
- (A) travel through space as changing electric and magnetic fields.
 - (B) travel at different speeds in a vacuum depending on frequency.
 - (C) carry energy.
 - (D) have momentum.
 - (E) can be reflected.

-

6

Which one of the following statements concerning electromagnetic radiation is false?

S17C

IV.4.b

111

E3

(D)

-

- (A) All forms of electromagnetic radiation travel at 3.0×10^8 m/s in a vacuum.
- (B) The particle nature of electromagnetic radiation becomes more obvious as the frequency increases.
- (C) Electromagnetic radiation is generated by accelerated charge.
- (D) The energy of electromagnetic radiation increases as the wavelength increases.
- (E) Electromagnetic radiation does not need a medium for its transmission.

7

The light emitted by a gas discharge tube is caused by

S17C

IV.8.d

112

A1

A2

(C)

-

**

- (A) friction between electrons in the tube.
- (B) escape of free electrons from the cathode.
- (C) return of excited electrons to lower energy states.
- (D) radioactive emanations from the gas in the tube.
- (E) radioactive emanations from the glass envelope.

WAVE/PARTICLE DUALITY

OF

ELECTROMAGNETIC

RADIATION AND MATTER

PHOTONS

- 1 A photon is
- S17C (A) a packet of light energy.
IV.6.a (B) a positively charged particle in the nucleus.
114 (C) a neutral particle normally found in the nucleus.
A2 (D) a continuous stream of radiation.
(A) (E) an electron excited by a strong electric field.

-
**

- 2 The existence of a cut-off frequency for the photo-
 electric effect supports the existence of
- S17C (A) matter waves only.
IV.6.c (B) light waves only.
114 (C) light particles only.
A9 (D) both light waves and light particles.
(D) (E) both matter waves and light particles.

-

- 3** A clean zinc plate is connected to a charged electroscope. The plate is illuminated with different kinds of electromagnetic radiation.
- S17A
IV.1.d
S17C
IV.6.c
- The charge on the electroscope will diminish permanently when the electroscope and the radiation respectively are
- S 114
- (A) positive and infrared.
- A1
- (B) negative and infrared.
- (E)
- (C) positive and red.
-
- ***
- (D) positive and ultraviolet.
- (E) negative and ultraviolet.

- 4** Consider the following procedures for emitting electrons from a metal:
- S17A
IV.1.e
S17C
IV.6.c
- I. bombard the metal with electrons
- II. place a strong electric field near the metal
- S 114
- III. illuminate the metal with light
- A2
- IV. heat the metal to a high temperature
- (E)
- Which of the above procedures can result in the emission of electrons?
-
- **
- (A) I only
- (B) II only
- (C) III only
- (D) IV only
- (E) I, II, III and IV

5

Several statements about the photoelectric effect are given below:

S17C

IV.6.c

116

A1

A8

(B)

-

I. The number of electrons emitted is proportional to the intensity of the incident light.

II. Whether or not photoelectrons are emitted depends on the frequency of the incident light.

III. The proportion of its energy which each photon transfers to each electron depends on the material used in the surface.

Which of the above statements correctly describes the photoelectric effect?

(A) I only

(B) I and II only

(C) I and III only

(D) II and III only

(E) I, II and III

6

S17C
IV.6.c

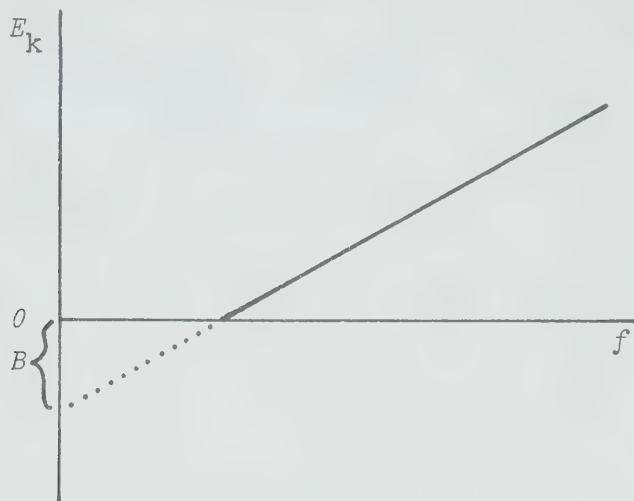
116

A11

(B)

-
**

An experiment is performed in which light of different frequencies is incident on the cathode of a phototube. The following graph represents the kinetic energy E_k of the most energetic photoelectrons ejected versus the photon frequency f .



According to Einstein's interpretation of the photoelectric effect, the equation of the line is

- (A) $E_k = hf$
- (B) $E_k = hf - B$
- (C) $E_k = hf + B$
- (D) $E_k = hB - f$
- (E) $E_k = hB + f$

7

The following statements are given by three students in an attempt to explain the photoelectric effect:

S17C

IV.6.c

116

A8

A1

(D)

-

I. Radiation energy arrives in packets, all packets having the same energy for a given frequency.

II. The energy delivered per second by a beam of blue light must be greater than the energy delivered per second by a beam of red light.

III. A photon of blue light has more energy than a photon of red light.

Which of the above statements is/are correct?

- (A) I only
- (B) I and II only
- (C) II and III only
- (D) I and III only
- (E) I, II and III

8

Which graph best represents the energy of a photon E as a function of its wavelength λ ?

S17C

IV.6.c

S 116

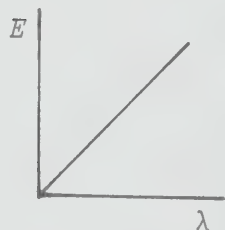
A11

A8

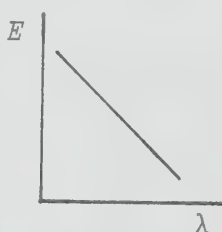
(D)

-

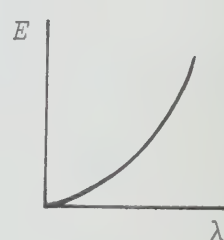
(A)



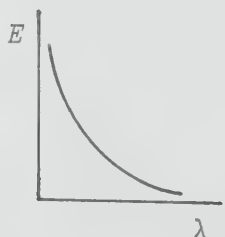
(B)



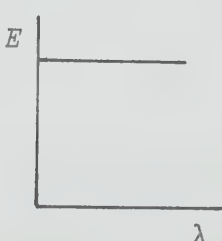
(C)



(D)



(E)



9

An experiment is performed in which light of different frequencies is incident on the cathode of a phototube.

S17C

IV.6.c

116

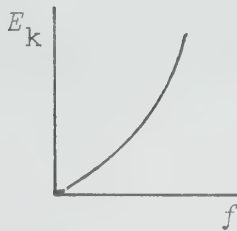
Which of the following graphs best represents the kinetic energy (E_k) of the most energetic photoelectrons versus photon frequency (f)?

A11

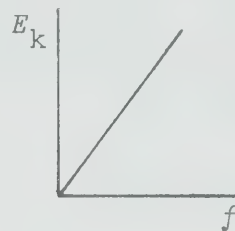
(E)

-

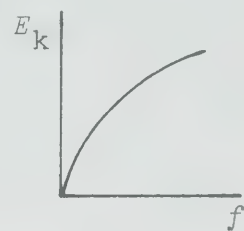
(A)



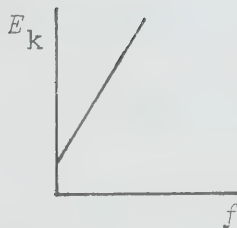
(B)



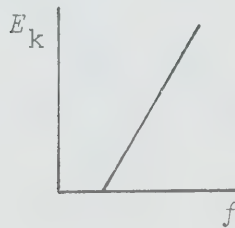
(C)



(D)



(E)



10

Which one of the following statements is true for a plane metal mirror which reflects 80% of the incident light falling on it?

S17C

IV.6.c

S 116

(A) Twenty percent of the incident photons are absorbed by the mirror.

(B) Each incident photon loses 20% of its energy on reflection.

(C) Different photons lose different amounts of energy on reflection, but the average energy lost per photon is 20%.

(D) The speed of each incident photon is greater than the speed of each reflected photon.

(E) The kinetic energy of each incident photon is greater than the kinetic energy of each reflected photon.

(A)

-
**

11

S17C
IV.6.c

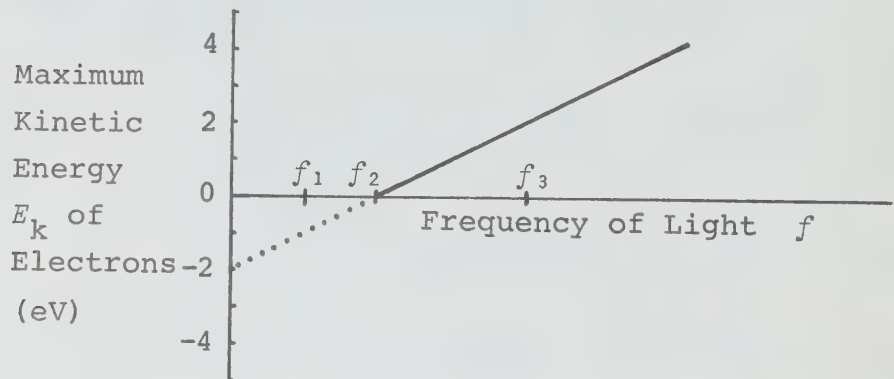
S 116

A11
A3

(B)

-

The graph below shows the maximum kinetic energy E_k of electrons emitted from the surface of a metal as a function of the frequency f of the incident light.



Consider the following statements:

- I. The energy of a photon of frequency f_1 is less than 2 eV.
- II. The energy of a photon of frequency f_2 is 2 eV.
- III. The energy of a photon of frequency f_3 is 2 eV.

Which of these statements is/are correct?

- (A) III only
- (B) I and II only
- (C) I and III only
- (D) II and III only
- (E) I, II and III

12

The energy of an electron which has been emitted from a surface by a photon depends mainly on the

S17C

IV.6.c

S 116

A11

(B)

-

- (A) energy of the electron before interaction with the photon.
- (B) frequency of the photon striking the electron.
- (C) number of photons striking the surface.
- (D) angle of incidence of the photon striking the surface.
- (E) speed of the photon striking the electron.

13

An electron volt is the

S17C

IV.3.e

117

A2

(C)

-

- (A) force acting on an electron moving through an electrical potential difference of one volt.
- (B) force required to move an electron through a distance of one metre.
- (C) energy gained by one electron moving through an electrical potential difference of one volt.
- (D) energy needed to move an electron through a distance of one metre.
- (E) work done when one coulomb of charge is moved through an electric potential difference of one volt.

14

Radiation of frequency f strikes a metal whose threshold energy is B .

S17C

IV.6.c

118

A8

(A)

-

If h represents Planck's constant, which one of the following expressions best represents the maximum kinetic energy of photoelectrons ejected?

(A) $hf - B$

(B) $hf + B$

(C) B

(D) $\frac{h}{f}$

(E) hf

15

A 4.0 eV photon is absorbed by a metal surface having a threshold energy of 3.0 eV.

S17C

IV.6.c

Which one of the following effects can occur at the surface of the metal?

118

116

F1

(B)

-

(A) Two electrons can be emitted, each with a kinetic energy between zero and 0.5 eV.

(B) An electron can be emitted with a kinetic energy between zero and 1.0 eV.

(C) An electron can be emitted with 3.0 eV of kinetic energy.

(D) An electron can be emitted with 4.0 eV of kinetic energy.

(E) An electron can be emitted with 7.0 eV of kinetic energy.

16

Radiation of frequency 4.0×10^{14} Hz strikes a metal whose work function is 1.2 eV.

S17C

IV.6.c

What is the maximum kinetic energy of photoelectrons ejected? ($h = 4.1 \times 10^{-15}$ eV·s)

118

116

F1

(B)

-

(A) 0.2 eV

(B) 0.4 eV

(C) 1.2 eV

(D) 1.6 eV

(E) 2.8 eV

- 17** Which one of the following statements pertaining to the photoelectric effect can be accounted for using the wave model of light?
- S17C
IV.6.c
- 118
- F1
- (B)
- ***
- (A) Photoemission is essentially instantaneous (10^{-9} s).
 - (B) The photocurrent I is directly proportional to the intensity of the light.
 - (C) There is a well defined maximum kinetic energy for the electrons which is dependent only on the frequency of the light.
 - (D) There is a threshold for photoemission which is independent of the intensity of the light and of the magnitude of the photocurrent.
 - (E) None of the above statements can be accounted for using the wave model of light.

- 18** Some substances will emit electrons when illuminated by any of the colours in visible light.
- S17A
IV.1.d
S17C
IV.6.c
- 118
- F1
A10
- (D)
- ***
- The emitted electrons will have the greatest kinetic energy if the light source is
- (A) blue
 - (B) green
 - (C) red
 - (D) violet
 - (E) yellow

19

S17C
IV.6.c

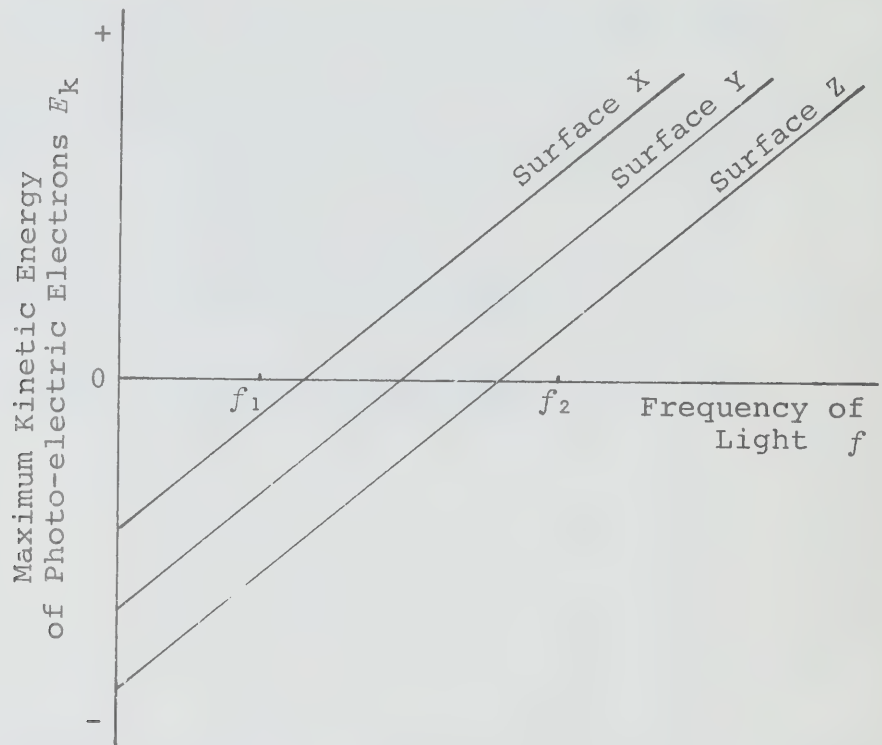
S 118

F1
All

(D)

-

Green, red, and violet light are shone on the surfaces of three different metals X, Y, and Z. Their photo-electric emission characteristics are shown below. Visible light has frequencies between f_1 and f_2 .



Which one of the given combinations will produce photo-electric electrons of the shortest de Broglie wavelength?

- (A) red light and surface X
- (B) green light and surface Y
- (C) green light and surface Z
- (D) violet light and surface Y
- (E) violet light and surface Z

20

S17C
IV.6.c

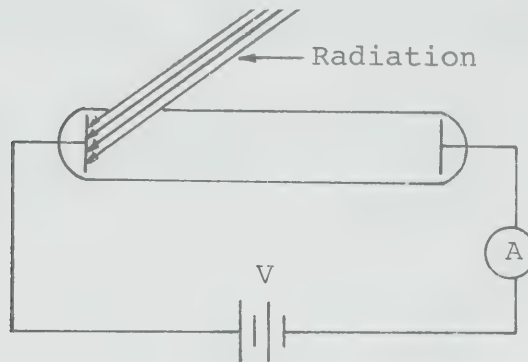
S 118

F1

(B)

-

Electromagnetic radiation falling on the emitting surface of a phototube causes a current to flow through the circuit.



Keeping all other factors constant, which one of the following changes will not result in an increase in the current through the ammeter?

- (A) using a different emitting surface with a lower work function
- (B) decreasing the distance between the emitting and the collecting surfaces
- (C) making the retarding voltage V more negative
- (D) reversing the polarity of the battery
- (E) decreasing the wavelength of the electromagnetic radiation

21S17C
IV.6.d

A thin mica foil is placed in a cloud chamber and bombarded with X-ray photons. A Compton collision occurs between a photon and an electron in the foil.

S 119

Which one of the following events is evidence of a Compton collision?

A10

(A)

-

- (A) The electron is ejected at an angle to the original direction of the photon with its own kinetic energy and momentum, while the photon emerges in a different direction with a larger wavelength.
- (B) The electron is excited to a higher energy level while the photon scatters with decreased energy and momentum.
- (C) The electron does not undergo any changes in energy or momentum and the photon scatters elastically.
- (D) The electron and photon are both annihilated in the collision.
- (E) The electron completely absorbs the photon and is ejected at an angle to the original path of the photon with all the energy and momentum.

22S17C
IV.6.c

If h represents Planck's constant and c represents the speed of light in a vacuum, which one of the following expressions best represents the momentum of a photon with a frequency f ?

120

A8

(C)

-

- (A) $\frac{h}{f}$
- (B) $\frac{hc}{f}$
- (C) $\frac{hf}{c}$
- (D) hf
- (E) $\frac{c}{hf}$

23S17C
IV.7.b

A particle has a de Broglie wavelength λ and a kinetic energy E_k ; (h represents Planck's constant and c represents the speed of light in a vacuum).

Which one of the following expressions best represents the mass of the particle?

120
123

A8

(A) $\frac{h}{\lambda}$

(E)

(B) $\frac{h}{\sqrt{2 \lambda E_k}}$

-

(C) $\frac{hc}{\lambda}$

(D) $\sqrt{\frac{h}{2 \lambda E_k}}$

(E) $\frac{h^2}{2 \lambda^2 E_k}$

24S17C
IV.6.d

If the speed of light is 3.0×10^8 m/s, the momentum of a photon having an energy of 3.2×10^{-19} J is

120

(A) 1.1×10^{-27} kg·m/s

F1

(B) 9.6×10^{-11} kg·m/s

(A)

(C) 6.7×10^{-9} kg·m/s

-

(D) 6.0×10^8 kg·m/s

(E) 4.2×10^{10} kg·m/s

25

If the speed of light is 3.0×10^8 m/s, what is the momentum of a photon with a frequency of 1.5×10^{14} Hz? ($h = 6.6 \times 10^{-34}$ J·s)

S17C
IV.6.d

120

F1

(C)

-

(A) $4.4 \times 10^{-48} \frac{\text{kg} \cdot \text{m}}{\text{s}}$

(B) $1.3 \times 10^{-39} \frac{\text{kg} \cdot \text{m}}{\text{s}}$

(C) $3.3 \times 10^{-28} \frac{\text{kg} \cdot \text{m}}{\text{s}}$

(D) $9.9 \times 10^{-20} \frac{\text{kg} \cdot \text{m}}{\text{s}}$

(E) $3.0 \times 10^{27} \frac{\text{kg} \cdot \text{m}}{\text{s}}$

26

If the speed of light is 3.0×10^8 m/s, what is the momentum of a photon which has an energy of 1.3×10^{-18} J? ($h = 6.6 \times 10^{-34}$ J·s)

S17C
IV.6.d

120

F1

(A)

-

(A) $4.3 \times 10^{-27} \text{ kg} \cdot \text{m/s}$

(B) $1.3 \times 10^{-18} \text{ kg} \cdot \text{m/s}$

(C) $3.8 \times 10^{-10} \text{ kg} \cdot \text{m/s}$

(D) $2.3 \times 10^{-8} \text{ kg} \cdot \text{m/s}$

(E) $1.7 \times 10^{11} \text{ kg} \cdot \text{m/s}$

27

What is the momentum of a photon whose wavelength is 700 nm? ($h = 6.6 \times 10^{-34}$ J·s)

S17C
IV.6.d

120

F1

A3

(B)

-

(A) $5.0 \times 10^{-40} \text{ kg} \cdot \text{m/s}$

(B) $9.4 \times 10^{-28} \text{ kg} \cdot \text{m/s}$

(C) zero

(D) $1.1 \times 10^{27} \text{ kg} \cdot \text{m/s}$

(E) $2.0 \times 10^{40} \text{ kg} \cdot \text{m/s}$

28

S17C
IV.6.d

Consider the following equations involving kinetic energy E_k , momentum p , mass m , speed v , wavelength λ , and Planck's constant h .

$$\text{I. } p = mv$$

$$\text{II. } E_k = \frac{pv}{2}$$

$$\text{III. } p = h/\lambda$$

S 120

A10

(A)

-

Which of the above equations apply(ies) to photons?

- (A) III only
- (B) I and II only
- (C) I and III only
- (D) II and III only
- (E) I, II and III

29

S17C
IV.6.c

This item involves two statements:

I. The penetrating power of a photon varies directly with its wavelength.

121

II. The energy of a photon varies directly with its wavelength.

A5

(E)

Which of the following responses correctly describes the two statements?

-

- (A) Both statements are true and one statement can be used to explain the other.
- (B) Both statements are true, but neither statement can be used to explain the other.
- (C) Statement I is true.
Statement II is false.
- (D) Statement I is false.
Statement II is true.
- (E) Statement I is false.
Statement II is false.

MATTER WAVES

1 Which one of the following is not an electromagnetic wave?

S17C

IV.7.a

(A) infrared ray

S 122

(B) light ray

A1

(C) matter wave

(C)

(D) microwave

-

(E) X ray

**

2

The wave theory of matter was first confirmed by the detection of

S17C

IV.7.b

(A) beta rays.

S 122

(B) gamma rays.

A1

(C) standing waves of atomic electrons.

(D)

(D) waves associated with free electrons.

-

(E) waves associated with moving molecules.

3 A given electron has a kinetic energy E_k and mass m .

S17C If h represents Planck's constant and c represents
IV.7.b the speed of light in a vacuum, which one of the
123 following expressions best represents the de Broglie
wavelength of this electron?

- A8 (A) $\frac{h}{E_k}$
- (B) $\frac{h}{\sqrt{2 m E_k}}$
- (B) $\frac{h}{2 m E_k}$
- *** (D) $\frac{hc}{E_k}$
- (E) $\sqrt{\frac{2 E_k}{m}}$

4 Which one of the following predictions is attributed to de Broglie?

- S17C (A) Matter waves are probability waves.
- IV.7.a (B) An atom can exist in different energy levels.
- 123 (C) Light can behave both as a wave and a particle.
- A9 (D) A moving particle has an associated wavelength.
- (D) (E) X rays can be diffracted by a crystal.
-
- ***

5

Boom Boom Slapshot fires a 200 g puck at the opposition goalie.

S17C

IV.7.b

If the puck travels at 100 m/s, what is the wavelength associated with the puck?

123

($h = 6.63 \times 10^{-34} \text{ J}\cdot\text{s}$)

F1

(A) $3.0 \times 10^{25} \text{ nm}$

(D)

(B) $3.3 \times 10^{-22} \text{ nm}$

-

(C) $1.3 \times 10^{-23} \text{ nm}$

(D) $3.3 \times 10^{-26} \text{ nm}$

(E) $1.3 \times 10^{-27} \text{ nm}$

6

By reflecting neutrons off a crystal and carefully checking the angle of reflection with a detector, it is possible to

S17C

IV.7.b

(A) find the diameter of the nucleus of an atom.

S 123

(B) find the index of refraction of the crystal.

A7

(C) find the isotopic abundance of the atoms making up the crystal.

(E)

(D) find the energy levels of the atom.

-

(E) verify the de Broglie wave equation.

7

Classical physics offered a satisfactory explanation for

S17C

IV.7.d

(A) deflection of charged particles in an electrostatic field.

S 124

(B) diffraction of electrons by crystals.

A10

(C) the intensity of black body radiation.

(A)

(D) the photo-electric effect.

-

(E) matter waves.

8

Which graph best represents the de Broglie wavelength λ of a moving particle as a function of its momentum p ?

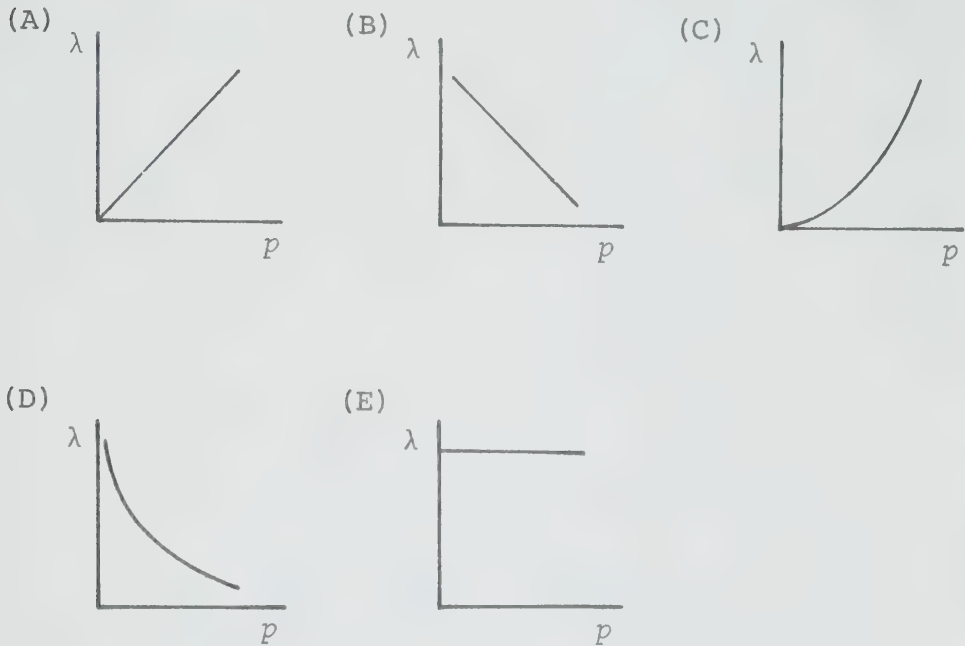
S17C
IV.7.b

S 123

A11
A8

(D)

-



9

To determine if interference occurs, shotgun pellets are fired at a sheet of steel containing two parallel slits 0.5 cm apart. Each slit is just wide enough so that a pellet can pass through.

S17C
IV.7.c

S 124

F1

(D)

-

An interference pattern is not observed because

- (A) matter waves do not undergo destructive and constructive interference.
- (B) matter waves from different pellets are changing phase.
- (C) the wavelengths of the matter waves are much larger than the separation of the slits.
- (D) the wavelengths of the matter waves are small compared to the size of the slits.
- (E) particles must be moving near the speed of light before matter waves are produced.

1

If an electron has the same de Broglie wavelength as a neutron, the momentum of the electron must be the same as the momentum of the neutron.

S17C

IV.7.b

(A) True

123

(B) False

A10

A8

(A)

-

T H E A T O M

THE RUTHERFORD MODEL

1 In the Rutherford "gold foil" experiment, the foil was bombarded by a narrow beam of

S17A

IV.2.d

S17C

IV.5.a

(A) alpha particles.

(B) beta particles.

125 (C) negative helium ions.

A1 (D) neutral helium atoms.

(A) (E) neutrons from a helium nucleus.

-

*

2 This item involves two statements:

S17C

IV.5.c

I. When alpha particles are fired at gold foil, most of the particles pass through the foil undeflected.

126

II. The atom is mostly empty space.

D3

(A) Which of the following responses correctly describes the two statements?

-

**

(A) Both statements are true and one statement can be used to explain the other.

(B) Both statements are true, but neither statement can be used to explain the other.

(C) Statement I is true.
Statement II is false.

(D) Statement I is false.
Statement II is true.

(E) Statement I is false.
Statement II is false.

3

The discovery that alpha particles are helium nuclei is attributed to

S17C

IV.5.d

(A) Francis William Aston

126

(B) John Joseph Thomson

I3

(C) Ernest Rutherford

(C)

(D) Marie Sklodowska Curie

-

(E) Antoine Henri Becquerel

**

4

Geiger and Marsden studied the scattering of α -particles caused by passing them through very thin metal foil. Their results indicated that the massive atomic centres differed in diameter from the diameter of the atoms themselves by a factor of 10^4 .

S17C

IV.5.d

SS 126

F1

This means that the density of nuclear matter is greater than the density of ordinary matter by a factor of

(D)

-

(A) 10^{-4} (B) 10^4 (C) 10^8 (D) 10^{12} (E) 10^{16}

5

S17C

IV.5

SS 126

F1

(C)

-

An oleic acid solution is made by dissolving oleic acid in alcohol. When drops of the solution are placed on the surface of water, the alcohol dissolves and the oleic acid spreads out on the surface to form a layer one molecule thick.

In an experiment, one drop of oleic acid solution formed an approximately circular monolayer film with a diameter of 16 cm. If four drops were used, the diameter of the monolayer would be

(A) 16 cm

(B) 24 cm

(C) 32 cm

(D) 48 cm

(E) 64 cm

6

S17C

IV.5.e

127

E3

A9

(D)

-

Consider the following predictions made on the basis of the Rutherford model of the atom:

I. Electrons in an atom will spiral into the nucleus.

II. The nuclei of atoms scatter alpha particles according to a Coulomb interaction.

III. Atoms will emit a complete spectrum of light rather than just some discrete colour.

Which of the above statements is/are inconsistent with the observed behaviour of atoms?

(A) I only

(B) II only

(C) I and II only

(D) I and III only

(E) I, II and III

ENERGY LEVELS

1 The experimental discovery that the energy of atoms increases in discrete steps is attributed to

S17C
IV.8.a

128

I3

(B)

-

- (A) Rutherford
- (B) Franck and Hertz
- (C) Taylor
- (D) Davisson and Germer
- (E) Bohr

2 An electron of kinetic energy 15.3 eV undergoes a single interaction with an atom having an ionization energy of 12.1 eV.

S17C
IV.8.b

129

A3

A1

(A)

-

Consider the following quantities of energy:

- I. 3.2 eV
- II. 12.1 eV
- III. 27.4 eV

If the atom is ionized on impact, with which of the above energies could the electron rebound?

- (A) I only
- (B) II only
- (C) III only
- (D) I and II only
- (E) I, II and III

3

An atom falls from an energy level E_2 to an energy level E_1 ; (h represents Planck's constant and c represents the speed of light in a vacuum).

S17C
IV.8.d

129
116

Which one of the following expressions best represents the wavelength of a photon emitted by this atom?

A8

(A) $\frac{h}{E_2 - E_1}$

(B)

(B) $\frac{hc}{E_2 - E_1}$

-

(C) $\frac{E_2 - E_1}{h}$

(D) $\frac{\sqrt{E_2 - E_1}}{h}$

(E) $\sqrt{\frac{hc}{E_2 - E_1}}$

4

An atom falls from an energy level of 9.1 eV to 6.7 eV.

S17C
IV.8.d

129
116

Given $h = 4.1 \times 10^{-15} \text{ eV}\cdot\text{s}$, the wavelength of a photon emitted by this atom is

(A) $1.7 \times 10^{-15} \text{ m}$

A8
F1

(B) $5.1 \times 10^{-7} \text{ m}$

(C) $2.0 \times 10^6 \text{ m}$

(B)

(D) $3.2 \times 10^{12} \text{ m}$

-

(E) $5.9 \times 10^{14} \text{ m}$

5

The diagram illustrates the energy levels of the atoms of metallic element X in a gaseous state.

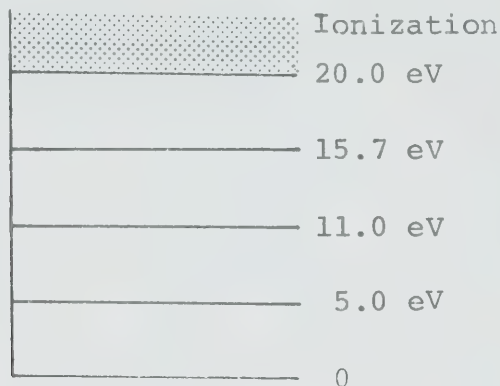
S17C
IV.8.c

129

A11
F1

(B)

-



If an electron with kinetic energy of 12.0 eV collides with an atom of X, with which one of the following energies would the electron rebound?

- (A) zero
- (B) 1.0 eV
- (C) 3.7 eV
- (D) 5.0 eV
- (E) 11.0 eV

6

The diagram illustrates the energy levels of the atoms of metallic element X in a gaseous state.

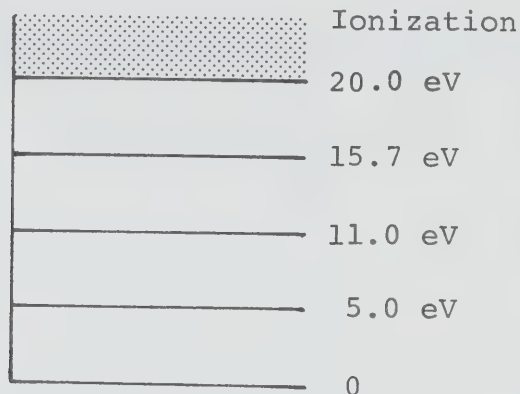
S17C
IV.8.c

129

All
Fl

(E)

-



If an electron with kinetic energy of 12.0 eV collides with an atom of X, with which of the following energies would the electron rebound?

- (A) zero
- (B) 1.0 eV only
- (C) 3.7 eV only
- (D) 7.0 eV only
- (E) 1.0 eV or 7.0 eV

7

Bohr's postulate concerning the existence of discrete energy levels in the hydrogen atom was given experimental support by

S17C
IV.8.d

129

I3

(A)

-

- (A) spectroscopic evidence.
- (B) matter waves proposed by de Broglie.
- (C) Rutherford's alpha scattering experiment.
- (D) Millikan's oil drop experiment.
- (E) Thomson's charge to mass ratio experiment.

8

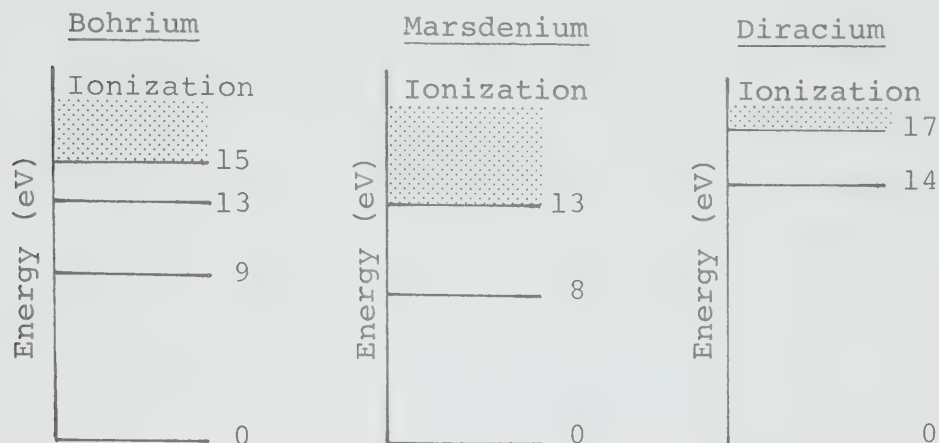
S17C
IV.8.d

131

The energy level diagrams for three hypothetical atoms, Bohrium, Marsdenium, and Diracium, are shown below. A sample of each atom is bombarded in turn by 16 eV photons and 16 eV electrons. Assume all possible transitions are made and that any captured electrons have zero energy on capture.

A3
A11

(A)

-
***

Which combination produces photons of the shortest wavelength when the atoms return to their ground states?

- (A) Bohrium bombarded by electrons
- (B) Marsdenium bombarded by electrons
- (C) Diracium bombarded by electrons
- (D) Marsdenium bombarded by photons
- (C) Diracium bombarded by photons

9

S17C
IV.8.d

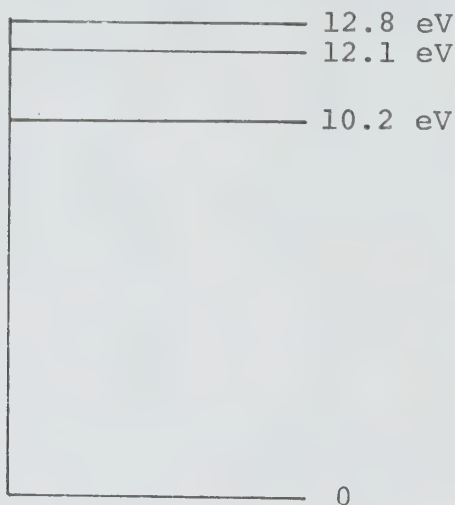
Part of the energy level diagram for the hydrogen atom is shown. Radiation, consisting only of 12.5 eV photons, is shone through a gas composed of atomic hydrogen.

131

A8

F1

(E)

-
***

What is the most likely composition of the transmitted radiation?

- (A) 10.2 eV photons only
- (B) 10.2 eV and 12.1 eV photons only
- (C) 10.2 eV, 12.1 eV and 1.9 eV photons only
- (D) 10.2 eV, 12.1 eV and 12.5 eV photons only
- (E) 12.5 eV photons only

10

S17C
IV.8.c

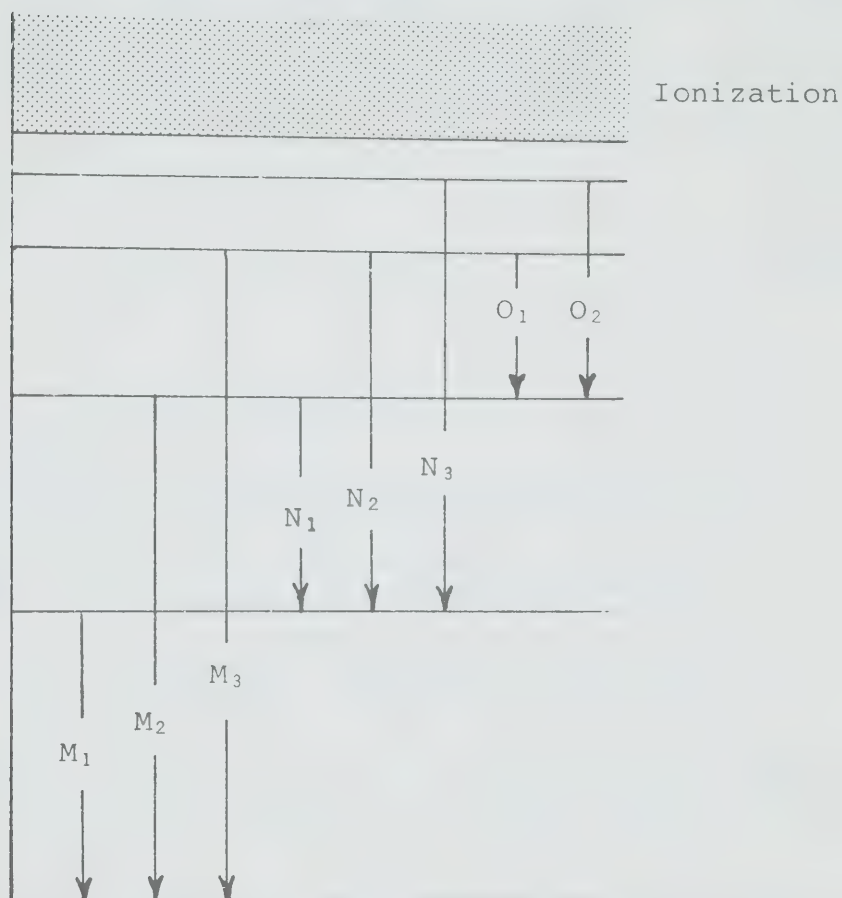
131

F1

(E)

-

The energy level diagram of atom X is shown below. The arrows show the energy changes for three sets of spectral lines characteristic of the atom.



If spectral line N_2 is visible in the emission spectrum of the atom, what other spectral lines, of those shown, would you expect to see?

- (A) N_1 only
- (B) N_1 and O_1 only
- (C) N_1 , N_3 and O_1 only
- (D) N_1 , O_1 and M_3 only
- (E) N_1 , O_1 , M_1 , M_2 , and M_3 only

11

The energy level diagram for the mercury atom is shown below.

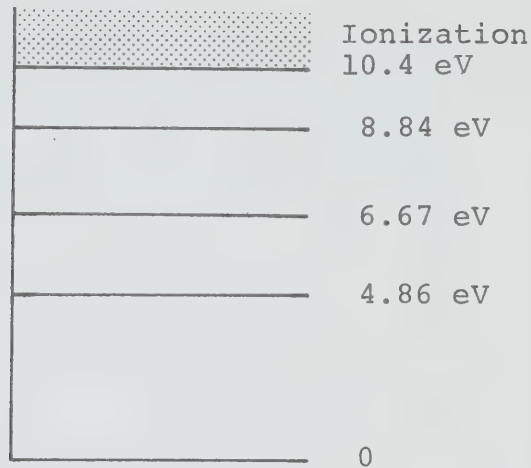
S17C
IV.8.c

S 131

A1
F1

(D)

-



A Franck-Hertz experiment was performed using an accelerating potential of 8.00 eV.

What are the possible energies of electrons after passing through the gas?

- (A) 4.86 eV and 6.67 eV only
- (B) 1.33 eV and 8.00 eV only
- (C) 0.84 eV, 2.40 eV and 8.00 eV only
- (D) 3.14 eV, 1.33 eV and 8.00 eV only
- (E) a continuum of energies from 0 to 8.00 eV

12

The energy level diagram for the mercury atom is shown below.

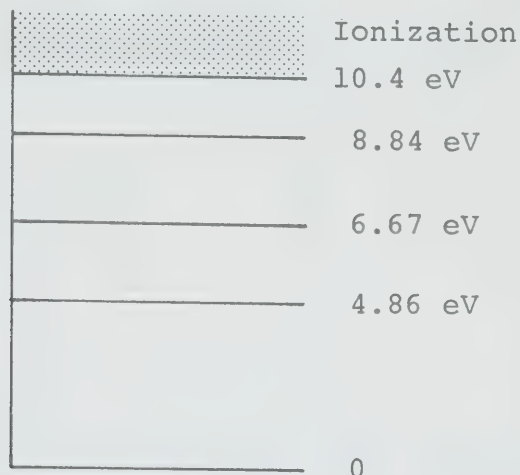
S17C
IV.8.c

S 131

F1

(B)

—



One sample of mercury vapour is bombarded with electrons of energy 8.40 eV and another sample with photons of energy 8.40 eV.

Which of the following statements is true?

- (A) The photons yield more information than the electrons about the internal structure of mercury.
- (B) The electrons yield more information than the photons about the internal structure of mercury.
- (C) The photons and the electrons yield identical information about the internal structure of mercury.
- (D) Mercury will interact with both the electrons and the photons.
- (E) Mercury will not interact with either the electrons or the photons.

13

The following diagram shows the energy levels of a hypothetical atom.

S17C

IV.8.e

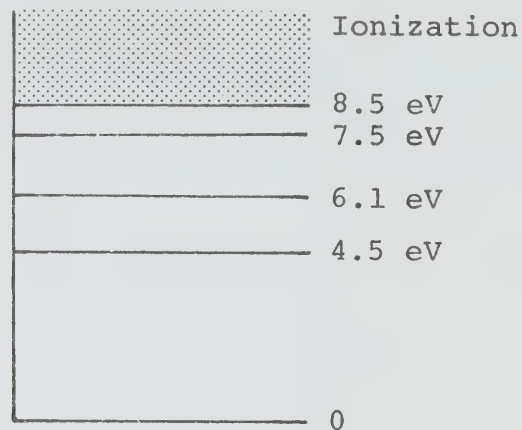
132

A9

F1

(B)

-



If a 6.5 eV photon hits this atom, the atom would absorb

- (A) all of the energy of the photon.
- (B) none of the energy of the photon.
- (C) only 4.5 eV of energy from the photon.
- (D) only 6.1 eV of energy from the photon.
- (E) either 4.5 eV or 6.1 eV of energy from the photon.

14

The energy level diagram for cesium is shown below.
($h = 4.1 \times 10^{-15} \text{ eV}\cdot\text{s}$)

S17C

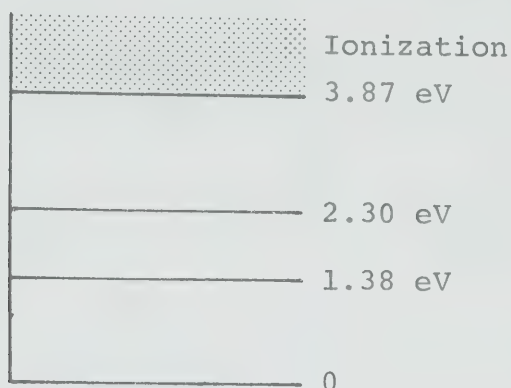
IV.8.e

132

F1

(C)

-



What is the longest wavelength of electromagnetic radiation that could be absorbed by a cesium atom in the ground state?

- (A) $3.2 \times 10^{-7} \text{ m}$
- (B) $5.3 \times 10^{-7} \text{ m}$
- (C) $8.9 \times 10^{-7} \text{ m}$
- (D) $1.3 \times 10^{-6} \text{ m}$
- (E) There is no 'longest' wavelength; any wavelength greater than $3.2 \times 10^{-7} \text{ m}$ could be absorbed.

15

The energy level diagram for cesium is shown below, where E_1 , E_2 , and E_3 represent the energy levels.

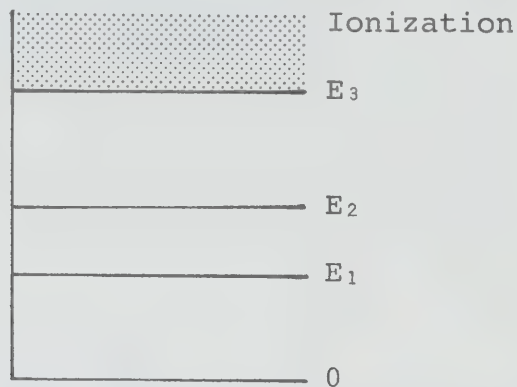
S17C

IV.8.e

132

F1

(C)



The symbol h represents Planck's constant and the symbol c represents the speed of light in a vacuum.

Which one of the following expressions best represents the longest wavelength of electromagnetic radiation that could be absorbed by a cesium atom in the ground state?

(A) $\frac{hc}{E_3}$

(B) $\frac{hc}{E_2}$

(C) $\frac{hc}{E_1}$

(D) $\frac{hc}{E_3 - E_2}$

(E) $\frac{hc}{E_2 - E_1}$

16S17C
IV.8.e

It is difficult for an observer on the Earth to determine by spectral analysis whether or not the atmospheres of Mars and Venus contain oxygen.

S 132

This is mainly due to the fact that

F1

(A) the planets only reflect the Sun's light and hence show the Sun's spectrum.

(E)

(B) the oxygen, if present on Mars and Venus, is not in an excited state and hence is not detectable.

-

(C) the atmosphere of Mars is too thin for accurate measurements while clouds on Venus make spectral analysis impossible.

(D) the orbital velocities of the planets relative to Earth cause Doppler effects which render the spectral measurements useless.

(E) any spectrum of Mars and Venus viewed from the Earth's surface shows absorption lines due to the oxygen in the Earth's atmosphere.

RAY

OR

GEOMETRIC OPTICS

REFRACTION

1

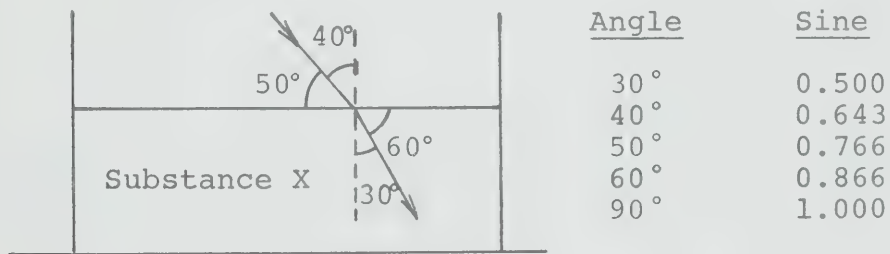
The following diagram shows the passage of light from air into substance X. The sines of several common angles are also shown.

SI7A
II.3.a
SI7C
II.1.b

285

F1

(C)



-

What is the index of refraction for substance X?

- (A) 0.74
- (B) 1.15
- (C) 1.29
- (D) 1.35
- (E) 1.47

2

The angle of incidence for a light ray emerging from water into air is 30° , as shown in the diagram. The sines corresponding to several angles are also given.

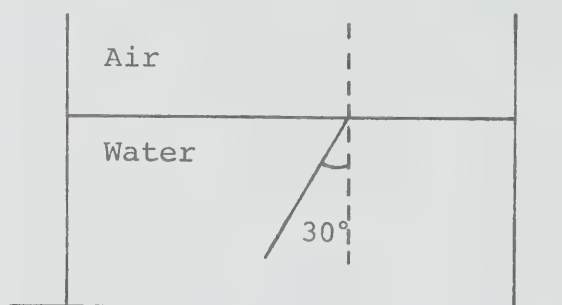
S17A
II.3.a
S17C
II.1.b

285

F1

(D)

-
**



<u>Angle</u>	<u>Sine</u>
19°	0.326
22°	0.375
30°	0.500
36°	0.588
42°	0.669
48°	0.743
60°	0.866
90°	1.000

What is the angle of refraction, if the refractive index of water is 1.33?

- (A) 19°
(B) 22°
(C) 36°
(D) 42°
(E) 48°

3

S17A
II.3.a
S17C
II.1.b

285

F1

(B)

-

A narrow beam of monochromatic light shines on a plate of glass with plane parallel surfaces. The index of refraction of the glass is 1.6. The sines of several angles are given below. The angle of incidence of the light is 30° .

The angle of emergence of the light from the glass is

<u>Angle</u>	<u>Sine</u>
18°	0.309
30°	0.500
48°	0.743
60°	0.866
72°	0.951

(A) 18°
(B) 30°
(C) 48°
(D) 60°
(E) 72°

4 The index of refraction of a sample of glass is 1.5.

S17A The sine of the critical angle for light incident on
II.3.a the glass-air boundary is
S17C
II.1.b (A) 0.50

287 (B) 0.67

F1 (C) 0.75
A8
 (D) 1.0

(B) (E) 1.5

-

**

5 A light ray travels in benzene toward air at an
 angle of incidence equal to the critical angle θ_c
 as shown in the diagram. The sines corresponding
 to several angles are also given.

S17A
II.3.a
S17C
II.1.b

287

F1

(C)

-

**

The diagram shows a horizontal boundary between two media. The upper region is labeled 'Air' and the lower region is labeled 'Benzene'. A vertical dashed line represents the normal to the boundary. A light ray is shown in the Benzene region, incident on the boundary at an angle θ_c to the normal. The angle is labeled with an arc and the symbol θ_c .

<u>Angle</u>	<u>Sine</u>
18°	0.309
22°	0.375
34°	0.559
47°	0.731
56°	0.829

Which of the following angles is closest to the critical angle, if the refractive index of benzene is 1.8?

(A) 56°

(B) 47°

(C) 34°

(D) 22°

(E) 18°

6

Burpium has an index of refraction of 2.0.

S17A
II.3.a
S17C
II.1.b

What is the critical angle for light passing from burpium into air? The relative dimensions and the angles contained by the sides of two common triangles are included for reference.

287

(A) 30°

F1

(B) 45°

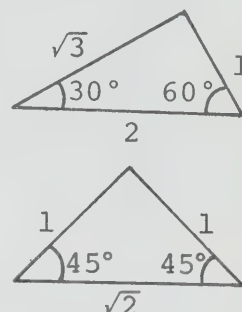
A2

(C) 49°

(A)

(D) 60°

-

(E) 90° 

7

Monochromatic light, travelling in a vacuum, strikes the surface of a liquid at an angle of incidence of 45° . The angle of refraction is 30° .

S17A
II.3.a
S17C
II.1.b

What happens if the same light, travelling in the liquid, strikes the surface of the liquid at an angle of incidence of 45° ? You may find the following angles and sines useful.

287

F1

AngleSine

(C)

 30°

0.5000

 45°

0.7071

-

 60°

0.8660

 90°

1.0000

- (A) The light leaves the liquid at an angle of refraction of 30° .
- (B) The light leaves the liquid at an angle of refraction of less than 30° .
- (C) The light leaves the liquid at an angle of refraction of about 90° .
- (D) The light stays in the liquid at an angle of reflection of 45° .
- (E) The light disappears completely.

1 When light travels obliquely from one transparent material to another, the sine of the angle of incidence varies directly with the sine of the angle of refraction.

S17C
II.1.b

285 (A) True

A11 (B) False

(A)

-
**

RADIOACTIVITY

AND

RADIATION EXPOSURE

RADIOACTIVITY

1

S17A
IV.1.b
S17C
IV.4.b

In an evacuated tube, electrons are emitted by a cathode and are accelerated toward an anode by a large potential difference. The electrons collide with the anode and are quickly brought to rest.

Which one of the following effects occurs as a result of this deceleration?

403
111

(A) The charge on each electron changes.

A1

(B) The mass of each electron increases.

(C)

(C) Electromagnetic radiation is emitted at the anode.

-

(D) All the energy lost by the electrons is converted to heat.

(E) All the energy lost by the electrons is stored as electric potential energy.

2

S17A
IV.1.c
S17C
IV.4.b

Which characteristic listed below is common to both electrons and X rays?

Both can

404

(A) travel at the speed of light in a vacuum.

(B) cause photoelectric emission.

A1

(C) ionize hydrogen atoms.

(C)

(D) be deflected by electric force fields.

-

(E) be absorbed completely during a collision with an orbital electron.

3

A small sample of a radioactive isotope is located between two oppositely charged plates X and Y in a vacuum.

S17A

IV.2.d

S17C

IV.2.a

407

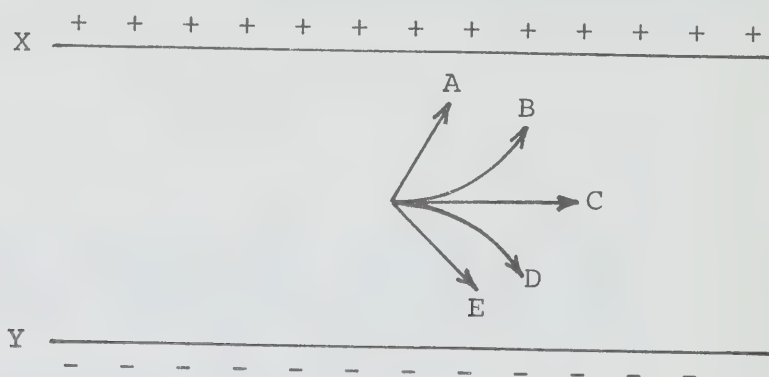
93

33

F1

A1

(D)



Which one of the paths shown in the diagram would an alpha particle (Helium-4 nucleus) follow after being emitted from the source? Assume the force due to gravity is negligible.

- (A) path A
- (B) path B
- (C) path C
- (D) path D
- (E) path E

HISTORICAL PERSPECTIVE

ASTRONOMY

KEPLER

1

Johannes Kepler developed his laws of planetary motion using accurate observations recorded by

S17C

III.3.a

(A) Nicolaus Copernicus

457

(B) Galileo Galilei

I3

(C) Tycho Brahe

A1

(D) Isaac Newton

(C)

(E) Claudius Ptolemy

-

2

The diagram below illustrates the path of an imaginary planet travelling in an elliptical orbit about a star X. The letters P to W represent positions of the planet in its orbit.

S17C

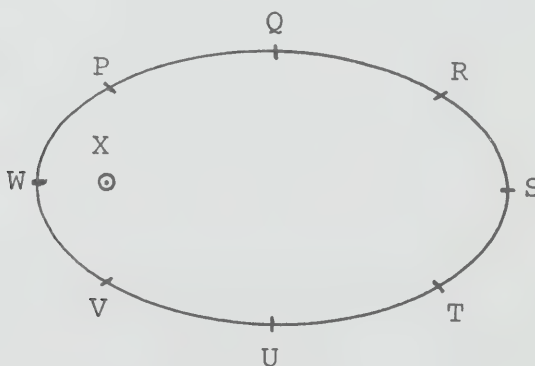
III.3.a

458

F1

(D)

-



At which point does the planet have the greatest speed?

(A) P

(B) U

(C) S

(D) W

(E) It has the same speed at all points.

1

Kepler's Law of Periods explains why there is a connection between the periods and mean distances of the orbits of the planets around the sun.

S17C

III.3.a

(A) True

458

(B) False

I2

(B)

-

GALILEO

- 1 Brahe's major contribution to the study of astronomy was the
- S17C
III.3.a (A) formulation of the inverse square law for gravity.
- 459 (B) formulation of the laws of planetary motion.
- A1 (C) introduction of the use of the telescope.
- I3 (D) development of the sun-centred theory of the solar system.
- (E)
-
- *** (E) precise measurements of the positions of the planets.

- 2 Copernicus' major contribution to the study of astronomy was the
- S17C
III.3.a (A) formulation of the inverse square law for gravity.
- 459 (B) formulation of the laws of planetary motion.
- A1 (C) introduction of the use of the telescope.
- I3 (D) development of the sun-centred theory of the solar system.
- (D)
-
- *** (E) precise measurements of the positions of the planets.

3

Kepler's major contribution to the study of astronomy was the

S17C

IV.3.a

459

A1

I3

(B)

-

**

(A) formulation of the inverse square law for gravity.

(B) formulation of the laws of planetary motion.

(C) introduction of the use of the telescope.

(D) development of the sun-centred theory of the solar system.

(E) precise measurements of the positions of the planets.

4

Galileo's major contribution to the study of astronomy was the

S17C

IV.1.a

459

A1

I3

(C)

-

(A) formulation of the inverse square law for gravity.

(B) formulation of the laws of planetary motion.

(C) introduction of the use of the telescope.

(D) development of the sun-centred theory of the solar system.

(E) precise measurements of the positions of the planets.

5

Which one of the following men pioneered the use of the astronomical telescope?

S17C

III.3.a

462

I3

A1

(D)

-

**

(A) Copernicus

(B) Brahe

(C) Kepler

(D) Galileo

(E) Newton

NEWTON

1

S17C
IV.3.a

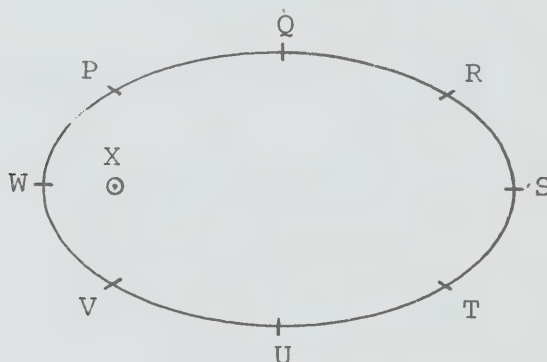
475

A2

(C)

-

The diagram below illustrates the path of an imaginary planet travelling in an elliptical orbit about a star X. The letters P to W represent positions of the planet in its orbit.



The perihelion distance of the planet is the distance

- (A) QU
- (B) WS
- (C) WX
- (D) XS
- (E) PV

2

Of the following list of planets, the one that was first discovered because its gravitational effect caused small irregularities in the orbit of another planet was

S17C
IV.3.a

- 480 (A) Uranus
F1 (B) Mercury
I3 (C) Venus
(D) (D) Neptune
-
*** (E) Saturn

3

The laboratory determination of the value for the Universal Gravitational Constant, G , is attributed to

S17C
IV.3.b

- 482 (A) Cavendish
(B) Coulomb
A1 (C) Galileo
I3 (D) Kepler
(A) (E) Newton
-

4

The major work of Brahe was done

S17C
IV.3.a

- 483 (A) before the time of Copernicus
(B) between the time of Copernicus and that of Kepler
(C) between the time of Galileo and that of Kepler
I3 (D) between the time of Galileo and that of Newton
A1
(B) (E) after the time of Newton
-

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V

